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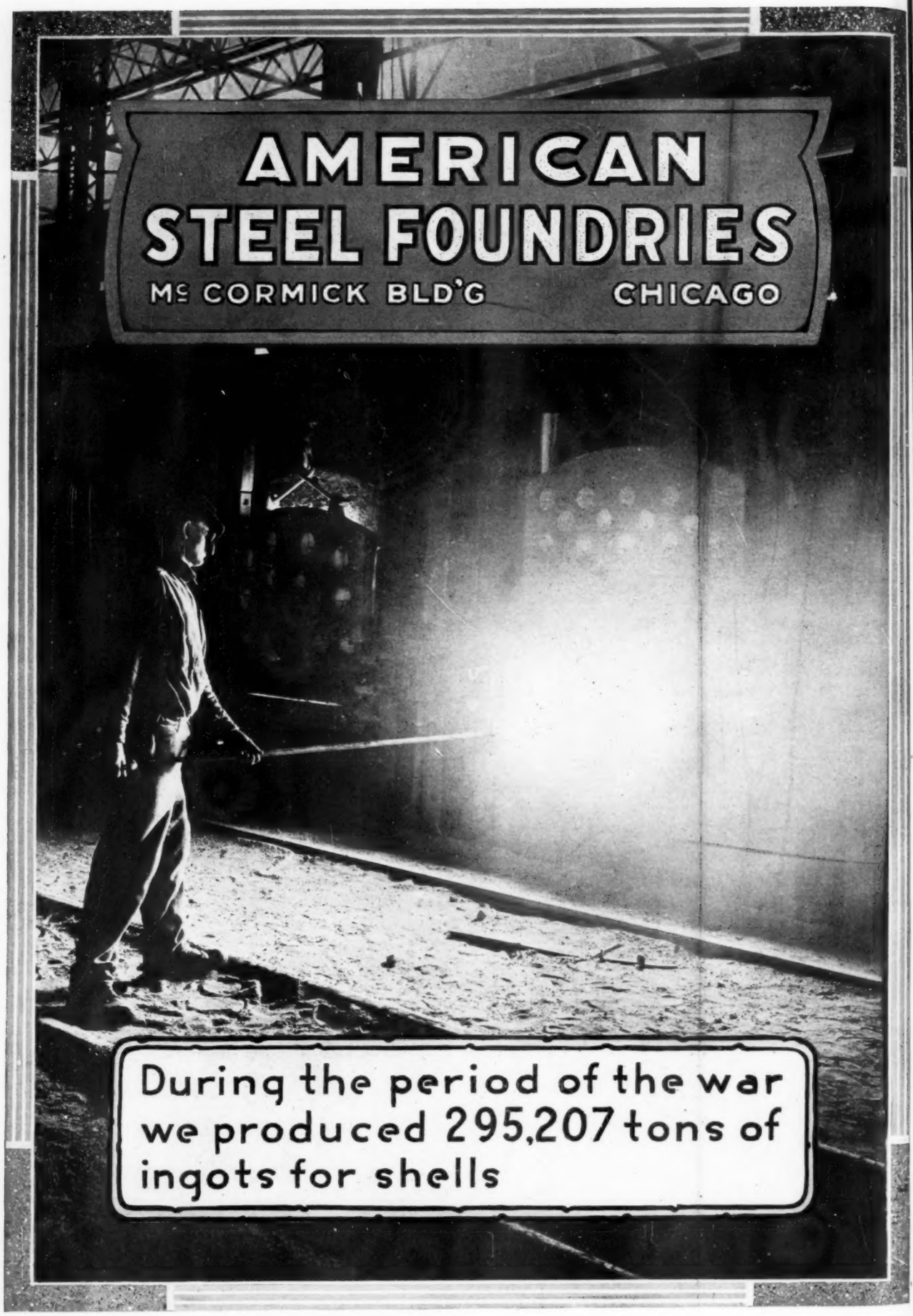
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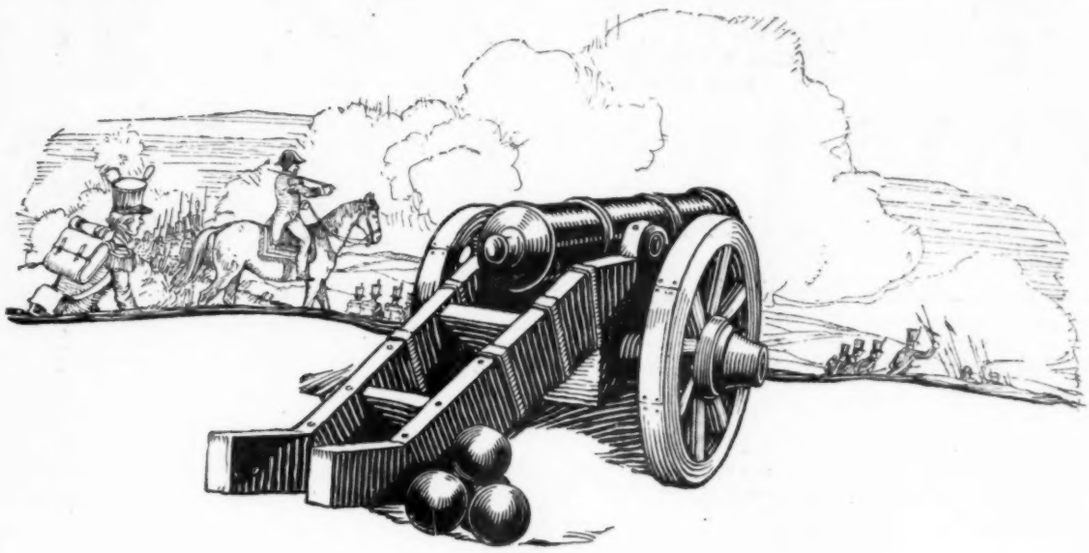

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Post-War Ordnance Development

A Critique

By

J. W. JOYES
Member A. O. A.

IT is now about three years since the Ordnance Department, marshaling its forces for the accomplishment of the duties of peace, was able to start an orderly study of the types of munitions which the World War had indicated as necessary for a successful and economical utilization of our man-power in future warfare.

A review, or critique, of the general progress and accomplishments of that period may well now be made and it is not inappropriate that such be offered by a member of the Technical Staff, that branch of the Ordnance Office organization to which is assigned the duty of taking counsel impartially with both user and designer, and of weighing with minds free from the influence of active work in design the considerations advanced by those with either viewpoint—the branch, in short, which plays a role embracing something of the mediator and more of the umpire.

COLONEL JOYES
Chief, Ordnance Technical Staff

There are few designs of the post-war period upon which records of completed test have yet been available for consideration, and it would therefore be premature to announce for the Ordnance Department definite opinions upon the satisfactoriness of individual types. But without passing final judgment upon such individual types and without pretense of speaking officially for the Ordnance Department, it should be possible to appraise the general progress made and to point out some of the apparent indications of the measure of success and of promise in that progress.

As general bases for the ordnance development program, there were several formal reports of Boards of Officers—for coast-defense artillery, the Board of Review; for artillery for the mobile armies, the Caliber Board or "Westervelt Board," and there have been other boards, occasional or continuing, whose dicta upon certain aspects of munitions and armament types have had their due influence. It has been the function of the Technical Staff, with the advice of the Ordnance Committee, to guide the active work of development generally along lines laid down by the reports of such boards, and always toward the best satisfaction of the needs of the using services—with due regard for priority of the needs most urgent.

There was not always interference of one project with another, nor were all projects of equal difficulty. Some proceeded along normal lines and had the assistance of ample experience, while others had to venture into almost untrodden paths or be pushed beyond what precedent would have indicated as the limit of practicability. Some projects, indeed, had their origin prior to the termination of hostilities, entering the period here under review with some headway and some achieved progress.

Thus, there is noteworthy accomplishment in the field of seacoast and railway artillery, wherein there have been fired with generally successful results such mammoth units as the disappearing and barbette mounts for the 16-inch, high-power guns of 50 calibers length and 25 miles range; the less powerful but still imposing 16-inch howitzer with its barbette mounting—a design having particular interest because of the provision for optional transfer when necessary of the howitzer and its tipping parts to a mobile railway mount.

The railway mounting for cannon has long had its advocates who saw in it a means of increasing the effectiveness of a given amount of armament in the defense of our long and exposed coast, as well as a means of avoiding disclosure of exact sites of emplacement. Besides these values, the great war of positions gave opportunity to demonstrate an additional value—that of the strengthening of a deployed force by fire of great power from positions in its rear. For such railway-mounted cannon as were used in the World War, targets stationary and of magnitude were the rule, changes of objective not frequent, and a rapid rate of fire not required. Even here, however, it was desirable—in coast defense it was imperative—that guns be capable of more convenient laying and that the recoil of the more powerful be so absorbed as to lessen or avoid car-recoil upon the rails. A noteworthy achievement has been the ingenious use of base-rings and turn-tables of obsolete seacoast mounts to allow convenient all-round (360°) laying for the 12-inch gun on the Batignolles railway mount. The safe and successful firing of this design opened the possibility of inexpensively providing numerous optional emplacements for each of the several Batignolles units. Other railway mount designs have been worked upon with a view to use either in support of land armies or in seacoast defense. A 14-inch, 50-caliber, high-power gun, mounted with all the refinements of advanced ordnance engineering upon a mobile railway mount, is at this writing about to be emplaced upon a turntable submounting at the proving ground, to undergo its proof.

In ammunition the outstanding aims have been improved armor-piercing projectiles and fuzes therefor, increased safety and certainty of fuzes, with reduction of the number of types required for different degrees of quickness in the bursting of field shell, maximum ballistic efficiency of the projectile itself, and improvements in propellants along the lines of reduced hygroscopicity and less visible flash. Armor-piercing projectiles of present specifications penetrate armor of caliber thickness at oblique impact angles as great as twenty-five degrees from the normal, and fuzes for such work function reliably and with good delay-action. Shrapnel and their fuzes were already about as efficient as could be expected with powder-train time-fuzes, but there has been some encouraging development of the mechanical time-fuze which, if successful, should be more reliable in anti-aircraft shell and less subject to deterioration in storage. Shell fuzes of latest design are secure against premature action in the bore of cannon and a single type gives, by a simple adjustment, either super-quick burst or short-delay after impact upon the ground. The principle of bore-safety will remove the main source of danger in transportation and storage of complete rounds of ammunition. Both range and accuracy have been increased by the better balance and the lessened air-resistance of the latest improved projectile designs. Propellant powders have been produced by several formulas which at the same time are less sensitive to atmospheric moisture and give much less muzzle-flash. As is usual, some disadvantages accompany these advantages—less flash entails more smoke, and ignition is difficult.

The experience of the World War put great emphasis upon the necessity to a land army of efficient artillery support, and demanded for such artillery improvements over war-types in the matters of range and mobility.

The Caliber Board embodied these teachings in the broad specification which it laid down for what it deliberately called the "ideal" type for each artillery mission.

In increasing the range of weapons, artillery designers were assisted by the advances made in ammunition during and after the war. Projectile design was so markedly improved as the result of extended experiment and analytical study that much greater ranges could be attained with a given muzzle energy.

Nevertheless, cannon and their mounts had to be designed for a great increase over previous types in developed muzzle energy. Muzzle energy is the measure of the stressing of the ordnance structure as it is of the output of the ordnance engine.

In the divisional artillery, such increased output was required without increase of weight limits because of the need that this matériel be still capable of draft by horses. Super-elevation and interchangeability requirements were also imposed.

The model of 1920 split-trail matériel thus comprising interchangeable 75-mm. gun and 105-mm. howitzer, and allowing 80 degrees elevation, has been fired with safety and success. It is slightly over weight and has suffered some damage in high-speed road tests.

The model of 1921 types are box-trail mounts each for the gun or howitzer only. They are lighter and more stable, due to non-interchangeability of cannon and reduction of elevation from 80° to 45°.

From the experience with these types, excessively drastic requirements and such faults of design as exist in them, will probably be eliminated so that redesign should give a highly efficient though not the "ideal" divisional matériel.

The Corps gun and howitzer and the Army gun and howitzer are not yet tested, but are expected shortly. Their mounts are of the split-trail type, similar to the 1920 division mounts, and likewise handicapped by interchangeability of gun and howitzer. An alternative split-trail mount for the 4.7-inch Corps gun is also under construction, following the 1921 division types in reduced elevation and in special design for the best results with the gun it mounts.

These types were all expected to be capable of hauling by tractors at as near as possible truck speeds, so they have rubber-tired wheels, and the heavier ones have springs. Nevertheless, fifteen-mile, or even twelve-mile speed over ordinary roads, is exceedingly severe on vehicles of such weight, and the results as to durability can not be predicted.

Tractors must haul their several artillery loads over rough ground and are asked to equal the speed of trucks on good roads. Types for division, corps and army—three, seven and fifteen tons respectively—have been designed and that for the division given some test. It was speedy but not of sufficient durability. Modifications are now under test. From all indications it is probable that some sacrifice must be made of either the desired speed or the durability—unless some new principle be forthcoming.

The same conditions as to desires and as to the inevitable severity of road-stresses at high speed are encountered in design of cross-country cargo-carriers (trailed or automotive), of self-propelled gun mounts and of tanks. Cargo-carriers thus far brought to test have been trailers and have afforded good engineering and other experience. They present their own problems—not least among which is the draw-bar. Final solution has not yet been reached.

Of self-propelled gun mounts there have been most interesting types produced. The 75 mm. 1916 gun on Mark VII mount (with twin-eight engine) brought out just after the war was very fast and nimble, but required too frequent repair. Two self-propelled motor carriages for the new division guns and howitzers have been produced—one of normal caterpillar type and one of the removable-track type to run on its solid-rubber-tired wheels when roads permit.

This latter principle—which has been used also in a mount for the 155-mm. G. P. F. and in a tank, etc., was a most interesting "prospect," but has thus far failed to show durability sufficient for military conditions. Whether the failures are due to defective application of the principle or to conditions inherent in the principle, it is hoped to discover as the result of tests now proceeding and of the ensuing study.

The value of self-propelled mounts for cannon must, of course, be determined by the combatant branches after the Ordnance Department has shown what ordnance engineering and automotive engineering in their present state of advancement are capable of producing in the matters of speed, weight and durability.

Three types of tanks were laid down—a wheel-caterpillar type, a normal caterpillar type and a similar one having a different type of track and suspension. The latter two have had little test and as the first has just been rebuilt and modified after short operation, the opportunity for comparison and appraisal is in the future.

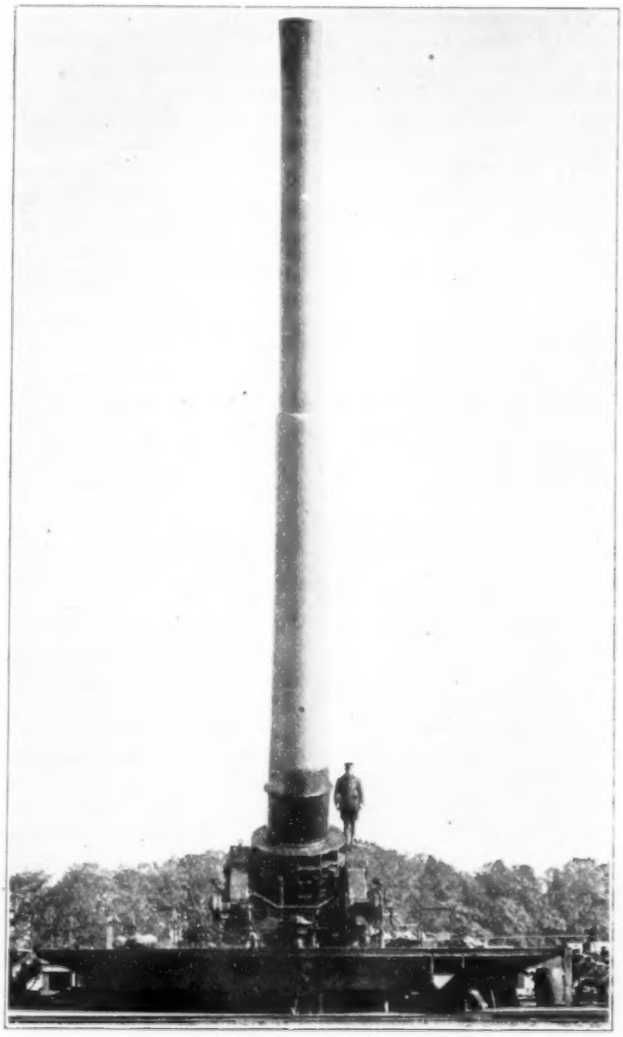
A number of very light automotive vehicles for cross-country work have been demanded and experimental types produced—one to carry the field artilleryman formerly individually mounted—others to carry small-arms ammunition and machine guns, etc. In such designs, the need for lightness suggested a flexible fabric track which has given promising results, not only on these types but applied to light standard commercial automobiles. Attempts to use this principle by applying to the heavy Militor truck a

flexible track made of steel wire cables has had results not satisfying but promising. There is even some hope of finding in this principle a means of obviating on heavy mounts, tractors and tanks some of the bad results of vibration and shock experienced with heavy articulated metal tracks—but confirmation of that hope waits upon progressive study and experiment, and cannot now be predicted with any confidence.

To revert to artillery, there has been produced a new pack howitzer which gave a good account of itself at the proving ground and which is now issued for a field test by the Artillery.

The Infantry's needs for various improvements in the rifle and its ammuntion have been studied and a number of special devices have been made for trial by the Infantry Board at Camp Benning. Improved ammunition, armor-piercing bullet, more knowledge of machine-gun ballistics and a caliber .50 machine-gun of probably satisfactory general type are among the accomplishments.

The Infantry howitzer problem has had very serious study in the effort to combine in a single weapon attributes of such different demands upon the matériel that by all experience they would be deemed impossible. Nevertheless accomplishment has been sought by study of the most radical and unorthodox expedients. The conviction now appears inevitable that a single weapon cannot be produced which will, with stable direct-fire, penetrate one-inch armor at reasonable distance and with high-angle fire drop high-explosive shell with accuracy at the desired minimum and maximum ranges, and yet be light enough for draft or carriage by men over bad ground. There is, however, hope of securing the two kinds of fire desired by two separate weapons much superior to the 37 mm. gun and the trench mortar used in the war.



16-Inch 50-Caliber Gun on Barbette Carriage
Front view at 65-degrees elevation

Among the new fields opened up, that of the bombs and other armament for aircraft use, and weapons for attack of aircraft has attracted much interest; it has been full of difficulties, which have been energetically attacked. Bombs of weights up to four thousand pounds have been devised and built and have been dropped with remarkably successful results—notably upon the occasion of the aircraft attack upon captured German war vessels. Bomb-fuzes are advanced to a state of marked reliability and safety, although further improvement may be sought in the ability to drop bombs "safe" from still higher altitudes. Satisfactory machine-guns are on hand and increase of power is assured for aircraft weapons, even if it should be found impracticable to give all that is called for by the enthusiasts.

A light and a heavy anti-aircraft gun are about to commence their test. They are most ingeniously devised as to the refined mechanisms for maneuvering and for laying—which permit keeping alignment upon the elusive target while applying adjustments to the gun.

Accessory instruments have been refined without any striking new developments. Studies are now proceeding along quite different lines to devise experimental apparatus for control of a group of anti-aircraft guns from a central station.

In the study of bomb and anti-aircraft ballistics no new theoretical principles or difficulties are involved, but the practical difficulties in obtaining data by observation are great. They have been attacked by several methods, the most promising of which is by cameras obscura—and an installation of the latest development on this principle is now advancing toward completion at the proving ground.

In the field of ballistics and ordnance theory, large advances in knowledge and in methods of work have been made during and since the war. This has been due to the combination—never before possible—of a considerable personnel of high scientific attainments and opportunity for extensive experimental firings.

Aside from the study of routine firing data and computation, tabulation and graphical plotting of data and function values, there have been some extended continuing programs of research. Among these stand out a series of observations upon the effect of air-streams upon various forms of projectile, the firing of projectiles of similarly varied forms in a standard gun for observation of perturbations in flight, experimental study of metal cylinders under internal fluid pressures below and above the elastic limit, and firings with a cannon on free-recoil mount with instrumental record of recoil-movement, chamber pressures, pressures and projectile movement throughout the bore and external velocity-measurement by several methods, including that by the newly developed induction solenoids. There have also been produced a valuable series of new range tables and ballistic tables.

In such progress in the several lines of development and research, it would seem that there is a creditable amount of achievement, considering the reductions in expenditure and in personnel that have been directed during the period in review; and there is certainly ground for the confident expectation of resulting types of American ordnance at least equal to those of any foreign power.

Notes on Interior Ballistics

By

W. H. TSCHAPPAT

Member A. O. A.

DURING the war period, intensive studies in exterior ballistics were made in all the principal combatant countries and the results applied in ammunition design. Compared with the time and expense devoted to this subject, the attention given to the study of interior ballistics was relatively insignificant. As to exterior ballistics, this may be accounted for by the marked improvements in range and accuracy obtained by proper designs of shell. Investigators in this field were thus encouraged by the definite and important results obtained.

In the study of interior ballistics and its application in the design of guns, such immediate results were, of course, not to be anticipated. Guns take longer to design and build than projectiles, and as a matter of fact relatively few new guns used in the war were designed during the war period. Aside from the German long-range gun, none of the guns that were designed during the war contained any important novel or improved features, except that they were generally more powerful than those of the same caliber which they were intended to replace.

The German long-range gun must have been as much an exterior as an interior ballistic problem. Its design and construction were probably not undertaken until the necessary weight and form of projectile, muzzle velocity, etc., to obtain the desired range had been fairly well determined. We have no absolutely reliable data as to the interior arrangement of this gun, but the best information we have seems to indicate that it differs from the ordinary gun of equal caliber principally in its great length and in the large capacity of the powder chamber, provision having been made for a charge of powder about twice the weight of the projectile.

The fact that in the great emergency a relatively small amount of attention was given to interior ballistic problems merely indicates that these problems are of such a nature that they must be worked out before rather than during a war. Interior ballistics is a study of the combustion of the powder charge in a gun and of the development of pressure in the resulting gases and of velocity in the projectile. Naturally, the weight and granulation of the powder, the weight of the projectile, the size of the powder chamber and the length of the gun must be considered in the study, as well as many minor factors which affect the result. In so far as it affects the design of the gun, this study fixes the size of the powder chamber as compared with the total volume of the bore. The powder chamber in a gun may be compared with the combustion chamber in an internal combustion motor or to the part of a steam engine cylinder in advance of the cut-off. Its importance is relatively as great. The study also establishes a curve of internal pressure which must exist along the bore of the gun to produce the desired muzzle velocity in the projectile. This curve of pressure is made use of by the gun designer as the basis of strength required in the various sections of the gun. A third result of the study is the finding of the proper size and form of granulation of the powder to be used in the gun.

In the early days of cannon, no attempt at an analysis of the force developed by the powder was made. The rapid reaction between the powder gas and projectile was looked upon as a case of impact. No means of even approximating the pressure developed was in existence. It soon was recognized that even with fine-grained, quick-burning powder then in use, the combustion of the powder took an appreciable time, and was not completed before the projectile commenced to move.

The development of the pressure gauge by Rodman and its improvement later by Nobel and Abel led to better knowledge of conditions in the gun. One of the first results of the invention of the pressure gauge was the development of powders of regular granulation with the size of the grain adapted to the gun. In the meantime instruments for accurately measuring muzzle velocity were also being developed and were replacing the old ballistic pendulum which gave only approximate results. Through the use of these instruments at proving grounds and elsewhere, data were rapidly collected and the next step was to build up such theories of the complete action of the powder in the gun as would reproduce the observed muzzle velocity and maximum pressure. A complete theory of this kind was worked out by M. Sarrau in the eighties. This work became a classic and the standard of reference for similar work for many years. Sarrau's method was worked out in the period of charcoal powders and the approximations which had to be made to get the formulas in usable form were found to be less applicable to the nitro or smokeless powder which came in a few years later.

Any theoretical treatment of the interior ballistic problem must take into consideration the following items:

(a) The energy released upon the combustion of a unit weight of the propellant powder used;

(b) The rate of combustion or the rate at which the energy in (a) is released.

Item (a) can be determined by modern calorimetric methods, but the energy or heat determined in the calorimeter is usually found to increase somewhat, for the same explosive, with the pressure developed in the calorimeter bomb. This increase becomes less as higher pressures are reached. For use in interior ballistics the heat or energy determination should be made at a pressure approximating that developed in the gun in which the powder is to be used. For best results a special calorimeter bomb, capable of withstanding an interior pressure of 40,000 pounds per square inch, should be used and determinations made at a pressure of about 30,000 pounds per square inch. The bomb should be large enough to take a few grains of the powder to be tested in their actual form. Ignition in the bomb should be obtained through an igniter of black powder or other flame-producing material rather than by filling the bomb with oxygen under pressure. The object of using a bomb as described is to reproduce conditions in the gun as nearly as practicable. For powders of small granulation, a bomb of the standard capacity used in testing coal, etc., may be used, but the walls should be thicker. For

powders of large granulations, special bombs of larger capacity as well as special calorimeters are required. Although the energy content of the powder is the very basis of its action in the gun we have not paid very much attention in our service to its accurate determination, having been satisfied to judge the powder by the results of its ballistic test in the gun. French experiments seem to indicate that if careful calorimetric tests, and rate of combustion tests described below, are made on a lot of powder, its action in the gun may be predicted and the ballistic test omitted or at least curtailed.

Item (b) above can be determined in a bomb fitted with a time-pressure gauge. The bomb might be the same as that used in the calorimeter but preferably should have a capacity sufficient for about 4 to 8 ounces of powder. It should be capable of withstanding a pressure of 40,000 pounds per square inch or more.

Several types of time-pressure gauges have been developed, or are under development, which are entirely suitable for use with this bomb. They may be classified as—

(a) Those which depend for their action upon the elastic distortion of a steel bar or spring,

(b) Those which make use of the Piezo-electric effect of crystals,

(c) Those which make use of the effect of pressure on contact resistance.

In all three types, the time record given by a tuning fork and the record of the gauge are both obtained on a rotating drum, usually photographically. Vieille and others have obtained results of pressure as a function of time with gauges of class (a) of a much more crude type than can now be supplied. Gauges of classes (b) and (c), now under development, should have advantages in accuracy over those of class (a).

If standard bombs were developed for determination of both the energy and the rate of combustion, many of the chemical and mechanical tests to which a lot of powder under manufacture is now subjected could be omitted. For instance, it would no longer be necessary to make determination of moisture and volatiles while the lot is drying, nor would it be necessary to make the detailed measurements of grain dimensions now required. The bomb tests, made periodically while the lot is drying, would indicate the gross effect of changes in volatiles, and of variations in grain dimensions from the standard. The bomb tests, when once standardized, could be made with much less expense and with greater accuracy than the chemical tests and grain measurements which they replace.

It is usual in the mathematical treatment of interior ballistics to divide the rate of combustion into two parts, one being the linear rate of combustion of the grain in a direction normal to the burning surface and the other being a function whose value is determined for each instant by the geometrical form of the grain. However, some writers, notably Charbonnier, do not make a rigid division but prefer to assign a value to the total rate of combustion determined by time-pressure experiments in a closed chamber. Beginning with Sarrau, all modern writers on interior ballistics accept the principle of combustion of the propelling charge in parallel layers, and the partly burned grains of powder thrown from guns almost daily at the Proving Ground yield ample proof of the correctness of this assumption.

Writers have generally assumed that the ignition of all grains of the charge is simultaneous, though Charbonnier's method permits of a variation in this. Most writers neglect the effect of the starting pressure, though it must be conceded that it will have a large effect upon the ignition of the charge and the early combustion and development of the pressure. Most writers also assume that the frictional resistance may be accounted for by assuming that it is a certain percentage of the total or of the accelerating pressure, and they accomplish this by adding a certain percentage to the weight of the projectile and thereafter neglecting consideration of friction as such. It is evident that this method leads to erroneous results when small charges are used, as the actual friction will be nearly the same as with large charges, while on the percentage basis the friction accounted for is very much less. To overcome this difficulty, one may assume that, while the passive resistance pressure is proportional at each point to the total pressure, the percentage is not the same for all charges, but varies as the ratio of the mean passive resistance, determined for the gun, to the mean total pressure on the base of the projectile.

One of the questions upon which there is very little experimental data is that of the relation between pressure and the linear rate of combustion of the grain. Very frequently, writers have taken this relation as a right line one, principally because the resulting equations could be readily handled, whereas any other assumption required the use of approximate methods of integration. The best data we have, as a result of Vieille's tests, indicate that this rate is proportional to the two-thirds power of the pressure.

The writer knows of no entirely satisfactory determination of this rate. The usual procedure is to deduce it from the time-pressure curve obtained in a bomb. This result is so involved with the question of form and simultaneous ignition of the grains used that there is considerable doubt about it. More direct experiments are called for.

The assumption of any other rate than the linear one produces difficulties in the general integration of the interior ballistic equations. In the past, such difficulties have been met by the use of empirical assumptions in accomplishing the approximate integration.

The development of the use of numerical integration enables the integration of the interior ballistic equations with the assumption of the rate of combustion proportional to the two-thirds power of the pressure to be made. Under the direction of Captain A. A. Bennett, the Ballistic Section of the Aberdeen Proving Ground has integrated the interior ballistic equations for a series of guns, a series of quicknesses of powder and a series of densities of loading. The results in the form of convenient tables permit the computation of pressure and velocity curves along the bore to be made at least as readily as with the empirical Leduc's formula.

All interior ballistic formulas have one or more constants which must be determined by firings or by closed chamber tests. In the usual proving ground experiments the measured data, with a given set of conditions of loading, are the muzzle velocity and the maximum pressure. This gives but one check each on the correctness of the pressure-space and the velocity-space curve, as worked out by the formulas. The proof of the formulas has been the application of this test to many variations in the conditions of loading.

In the 240 mm. howitzer interior ballistic program now in progress at the Aberdeen Proving Ground, measurements are being obtained of the space-time relation and of the pressure-time relation along the bore. The data thus obtained should serve as a complete check upon theoretical pressure and velocity curves, and should lead to improvements in theoretical interior ballistic formulas. It remains to be seen whether the results of these tests will increase the confidence of the gun designer in theoretical interior ballistic methods or the reverse.

The Ordnance District System

By

W. S. PEIRCE

Member A. O. A.

IN reviewing the question of the procurement of munitions in the light of the experience gained by the Ordnance Department during the World War, two important facts stand out clearly:

1st, An effective war-time procurement agency must be organized upon a subjective ("commodity" or "vertical line") basis rather than upon functional lines; and 2nd, The production and inspection and, to a very large extent, the procurement must be decentralized.

The difficulty with the functional type of organization in war is that events move too rapidly. The organization is not flexible nor does it adapt itself to expansion. It is necessary that responsibility for the procurement and production of an article should be very definitely located. This means that the responsibility for every stage involved in securing a given article—engineering, procurement, production, inspection—must in the last analysis rest upon a particular individual. The interest of the *using service* is in *delivered* articles only. The responsibility of the supply service is that the using service should get these articles *when they are wanted, where they are wanted, and in the quantity wanted.* The supply service can act intelligently only when some responsible individual knows the entire situation regarding each particular article; stocks on hand, quantities in process and their prospective deliveries, etc. To get an intelligent idea of the situation is practically impossible when one individual knows only engineering, another only procurement or production, a third only stocks on hand, etc.

The reasons for decentralizing production and inspection and the greater part of procurement are clear. The congestion of manufacturers' representatives in Washington endeavoring to secure data to which they were clearly entitled very materially interfered with the functioning of the Ordnance Office during the greater part of the World War. It necessitated long trips on the part of these individuals to secure data which could have been given them to better effect nearer home. To secure the desired decentralization, the district system was established during the war and was working fairly satisfactorily at the time of the armistice, although it had not yet reached its full development. Its effect in relieving the central office of an enormous burden of detail was markedly apparent.

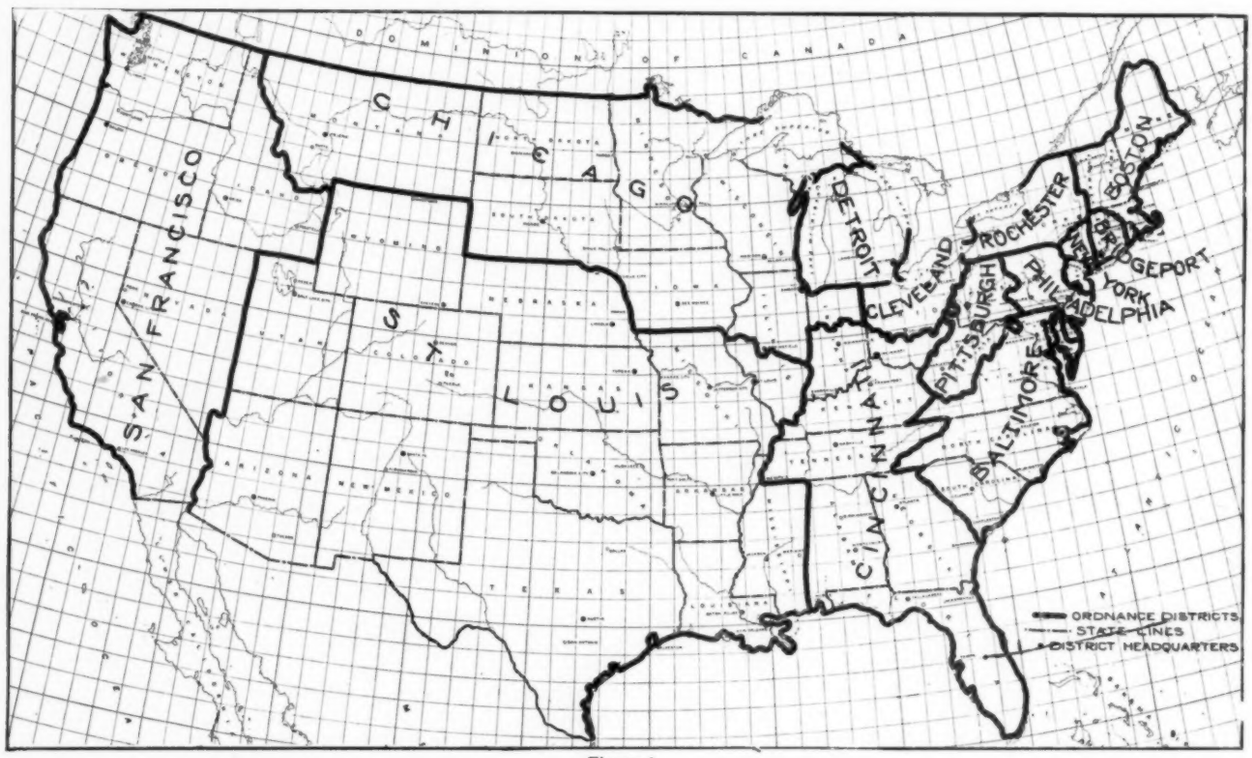


Figure 1

The present organization of the Manufacturing Service of the Ordnance Office is along vertical lines. For instance, all questions in regard to artillery are handled by the Artillery Division. This division is further subdivided along the same lines into the Cannon Section, the Fire Control Section. etc.

As a part of the Industrial War Plan of the Ordnance

Department, the district system is now being reestablished for use in the event of an emergency. The country has been divided into 13 districts as shown in Figure 1. This division is an industrial one and attempts to assign to each district headquarters the territory naturally tributary to it in an industrial sense, while at the same time keeping the number of districts to a minimum. These districts are substantially the same as during the World War with the exception that the St. Louis District has been divided and the new San Francisco District established in what was previously St. Louis District territory.

It is proposed to give district offices greater scope than was the case previously in that they will also handle a great portion of ordnance procurement. In the case of a few articles, it will be desirable for procurement to be centralized in Washington.

The organization of each district office will parallel that of the Manufacturing Service of the Ordnance Office. The typical organization chart is shown in Figure 2. It will be noted that each District Office is subdivided into divisions

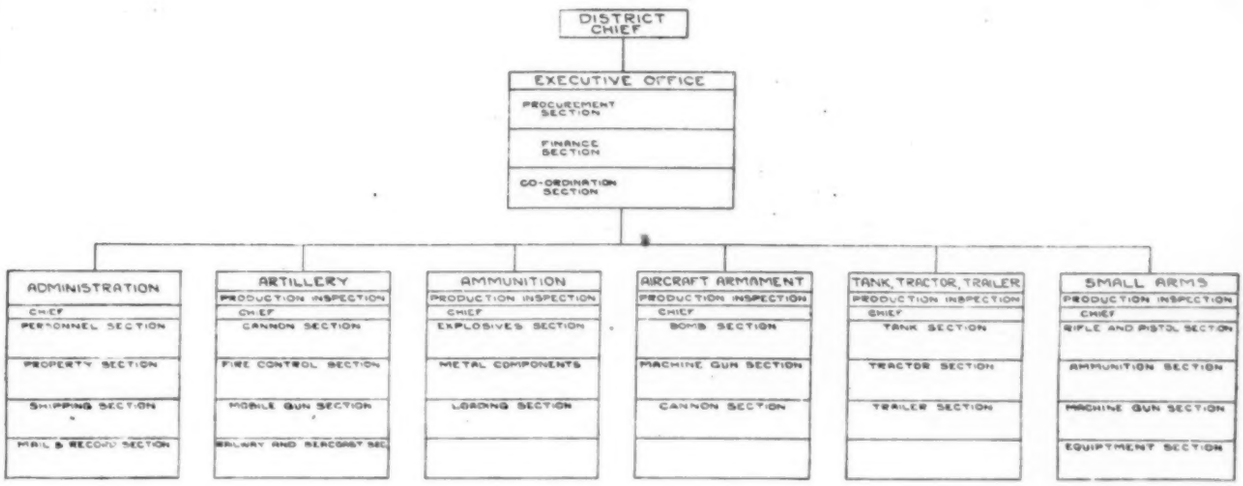


Figure 2

to correspond with those of the Manufacturing Service. In all technical matters not requiring action by the District Chief or the Chief of Manufacture, correspondence will be direct between these divisions. To illustrate, the Artillery Division of the Manufacturing Service in Washington will deal directly with the Artillery Divisions of the various District Offices. This will greatly facilitate the transaction of business and avoid the old difficulty due to inability to locate the proper officer to do busness with in Washington.

In each district, only those divisions will be established which correspond to the material being procured. There would, of course, be no reason for establishing a Small Arms Division in a District where there is to be no procurement of small arms material.

A peace-time nucleus of each ordnance district is being established by the detail from the Regular Service of an executive assistant for each District Chief. These assistants will work under the informal direction of the District Chiefs, and it will be their duty to secure information which will enable the Ordnance Office to allocate, as far as it may be possible, to particular factories the kind and quantities of munitions which it is expected to procure from these factories in the event of war. He will also furnish the factory heads with drawings and data concerning the material to be procured.

In order to determine just what is to be procured in each district in the event of an emergency, it is first necessary to determine what the total requirements of ordnance will be. The sources of data from which the problem is worked out are:

The official man-power mobilization curve and schedule of entrance into the theatre of operations established by the General Staff;

The approved tables of organization and tables of basic allowances;

General Staff data as to training allowances and combat rates of fire;

Data in regard to necessary spare parts and replacements based on Ordnance Department experience in the recent war.

From the above data, it is possible to establish cumulative requirements for the army and plot curves showing these requirements by months for each principal article for which the Ordnance Department is responsible. These curves are the bases on which the Ordnance production program is to be worked out and the necessary war reserves established.

The cumulative requirements curve for any component having been established, the problem becomes an entirely definite one, namely, to establish an adequate reserve and plan the necessary production to meet the curve. The theoretically ideal solution would be to plan a war time production program which would ultimately just suffice to take care of the consumptive requirements of the maximum number of troops in training and in the theater of operations and to maintain a war reserve to take care of all requirements in excess of those which could be taken care of by this production program during the period of mobilization and until production became fully established. It is needless to state that this ideal solution will rarely or never be attained. The enormous cost of the war reserves required renders the attainment of the ideal solution impracticable.

It is to be borne in mind, too, in working out requirements that production usually falls below estimates and that it is much worse for the supply services to fail to meet requirements than it is for them to over run. On the other hand, it is also to be borne in mind that the cost of prosecution of a war is a tremendous burden on the country and that unnecessarily excessive production would add very materially to this burden. The attempt should be to attain the safe side of the happy mean.

It is intended that all facilities under control of the Ordnance Department shall be placed in maximum produc-

tion as soon as the need therefor presents itself. Simultaneously, such civilian industrial plants as can most readily be converted to our needs must also be started. Finally, whatever additional facilities are necessary to completely meet the program must be provided. The provision of these facilities must begin as soon as their need is manifest or can be anticipated.

The consolidated requirements for all articles of Ordnance supply, arranged by components to be procured from manufacturers or arsenals rather than by assembled articles for issue, are arranged on "D-day order sheets." These sheets also include the estimated cost of the material and source or sources of procurement of each article. On the occurrence of an emergency, there will only remain to secure the necessary funds from Congress and place orders and contracts in accordance with the D-day order sheets.

It is the intention that as much of the requirements as practicable will be definitely allocated in advance to each existing plant that is to be engaged in the production of munitions, so that there will be opportunity for studies to be made by the officers or other officials concerned, with the idea of balancing the plants and making all other preparations, to the end that production in all existing facilities can be gotten under way with great promptness. Of course, this can be done much more definitely for the material to be manufactured at Government arsenals than it can for the material to be manufactured by civilian agencies. Nevertheless, every step will be taken that it is possible to take, to insure that the necessary plans are prepared, special tools, jigs, fixtures, etc., provided for, etc., etc. As far as practicable, changes will be avoided in types after they have once been officially adopted for the service. Suggested changes and improvements which may be very desirable in themselves will be held to be incorporated in later models rather than put into adopted types.

Another important feature of the present organization is that each manufacturer will look to but one individual as the source of authority and information concerning his contract. All dealings of the Ordnance Department with each manufacturer will be through the senior Ordnance representative at the plant, so that the succession of visiting officers, each apparently armed with the authority of the Chief of Ordnance and giving conflicting instructions and orders which occurred in too many instances during the recent war, will be avoided in the future.

In the transition stage in the beginning of a war, it will be necessary to spread out the special skill and experience available at the various manufacturing arsenals among the districts. It is contemplated to secure this result by commissioning in the Reserve Corps qualified civilian employees at the arsenals to the end that the available knowledge and experience may be disposed of to the best interests of the Government in time of war. To illustrate, the Pittsburgh District will doubtless be a source of gun forgings in the event of an emergency. The District Chief will need on his staff to handle questions of procurement, production and inspection an expert whose experience has been with gun forgings from the government viewpoint in time of peace. This individual can be secured from but one place, namely, Watervliet Arsenal. Watervliet Arsenal will be charged with the duty of training such an individual and having him prepared to take up his duties in the Pittsburgh District in the event of war. He will hold a reserve commission and be immediately available for duty in the Pittsburgh district in time of war.

The full development of the District Office scheme will be a matter of several years. Many questions remain to be solved in the light of the experience we shall gain as the work proceeds. In the meantime, full and free criticism of the plan in general and in detail will be welcomed.

Bernard M. Baruch *on* Industrial Preparedness

In a recent address quoted in the *Army and Navy Journal*, Mr. Bernard M. Baruch, who was head of the War Industries Board during the World War, advocated the creation of a body for industrial war planning in time of peace. He said in part:

"Wars were fought and won—or lost—on the land, on the water, in the air and on those battle lines behind the front where the civilian forces stand.

"It is not enough to mobilize the nation's military strength; there must be a mobilization of its full financial, economic, agricultural and industrial resources. These must be organized, coordinated and directed with the same strategy that governs the operations of the service.

"The prodigious strain upon the country's productive capacity must be met and balanced to provide the means of warfare, to maintain the civilian population and to preserve the economic fabric as much as possible.

"The resources of the country can be briefly enumerated as follows: Men, money, maintenance, materials and morale. The first four, men, money, food or maintenance and materials should be mobilized in such a way that the fighting forces of those commanding them will be able to draw upon these resources at will, both for offensive and for defensive measures. The purpose of these in connection with the civilian population tends to keep up the morale of the community. That is of very great importance, because without good morale back of the fighting forces there can be no real success.

"To control and regulate industry in its direct and indirect multitudinous relations, to synchronize and co-ordinate the whole, the President in the World War created the War Industries Board and placed the responsibility and necessary authority for its operation in the hands of a chairman.

"I have made a recommendation in my report to the President for an industrial organization similar to the one that was in effect at the closing of the war, to be continued during peace so as to be prepared. My idea in this recommendation is that the country shall be so self-contained that it will be possible for it to be surrounded for years by enemies and yet be able to conduct war with great efficiency, maintaining all the while the morale of its people.

"It is my theory that the fighting arms of the nation should decide upon the kinds of fighting forces it wants, the kinds of material, guns, munitions, airplanes and the like that it should have, and that it should give orders for those munitions and instruments of war as well as follow up their production and inspection.

"It should be the purpose of this suggested industrial body to learn how and where it could best place those orders and be most certain of their being filled. This should be done with the thought in mind of eliminating congestion or inability to move its forces, its products or supplies necessary to keep alive the civilian population.

"The industrial strategists should point out where supplies should be ordered so that they would be obtained without conflict and congestion, when they should be ordered and in what part of the country the orders should be given. The industrial board would say what industries were key industries and what class and character of men should be spared, and what class and character of industries should be entirely eliminated or cut down.

"Finally, this industrial body should be able to give to the President, Secretary of War, Secretary of the Navy and Chief of Staff within a week's time almost exactly what they could expect in equipment, food, material and men. This should include information as to converting industries quickly from a peace to a war basis.

"In other words, an industrial board should have resources of men, money and materials mobilized so that the fighting forces could go to it like a private individual goes to a big store to get whatever he needs when and as he needs.

Aircraft Guns

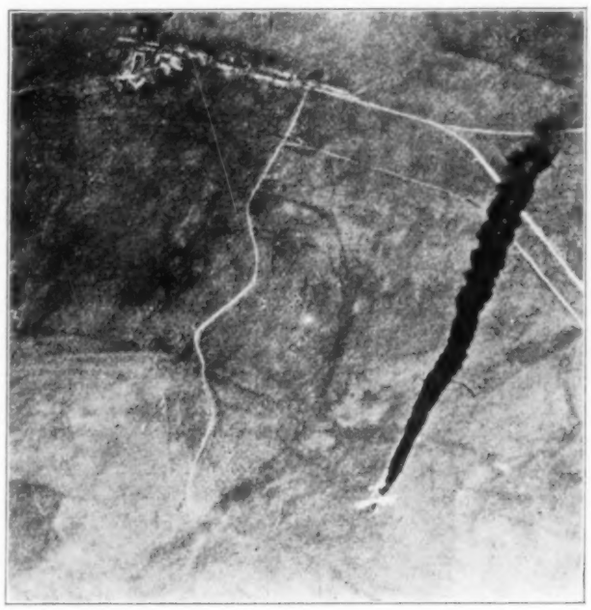
PART I

By

WM. A. BORDEN
Member A. O. A.

THE race is on in the development of offensive weapons of the air. Many are familiar with big gun development as applied to the arming of vessels of war which as time progressed became a contest of guns versus armor. First armor on ships would be thickened and strengthened sufficiently to withstand the impact of projectiles from the guns and then guns would be increased in caliber and in power and the improved armor would be pierced. For years this contest has been going on and wonderful improvements in guns and armor have been made.

Now we are witnessing the first period of another and similar race, aircraft guns versus armor on aircraft, and even those who are familiar with the first efforts in this race have probably only a very slight appreciation of what will develop in the next hundred years. Without venturing a prediction, a glance at the development of aircraft guns to the present day may indicate the possibilities of the future.



Shot Down in Flames

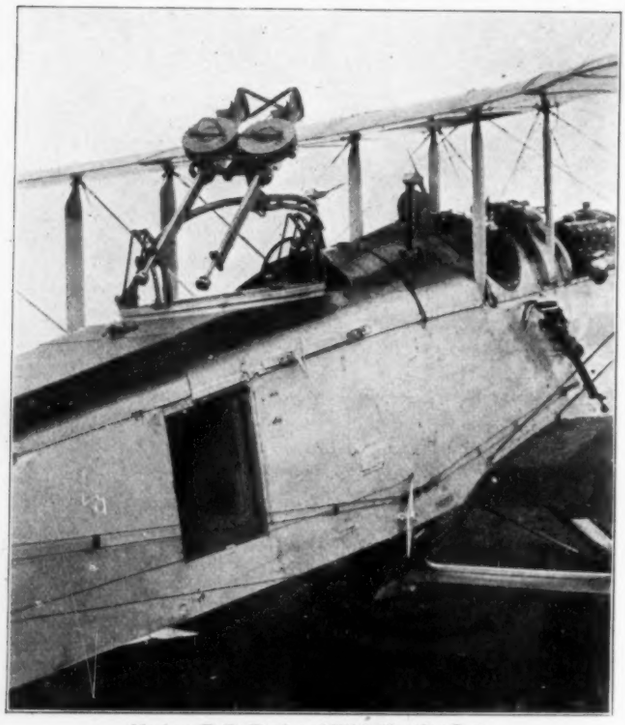
A bombing airplane has just been successfully attacked by a pursuit plane which can be seen just above the trail of black smoke marking the downward course of the vanquished bomber. The photograph was taken from an observation airplane far above the level of the attack.

Offensive efforts on the part of aircraft against other aircraft were initiated in the past war though it is probably impossible to find out who actually started this new style in warfare. We know that the first machine gun was fired from an airplane in the United States at College Park, Maryland, in 1912. Guns for air use were, however, not developed until after the war started when airplanes had become more stable machines.

The first use of airplanes during the war was for observation. The art of flying was then only slightly advanced past the initial stage and the actual risk taken in piloting an airplane was sufficient in itself without being complicated by attempts to prevent someone else from flying. However, as the activities of the airplane became greater and its value as a source of advance information indispensable, military necessity required that the enemy's activities of like nature be curbed. Firing at airplanes from the ground at this stage, although freely indulged in, merely wasted ammunition, for without anti-aircraft fire control only a very rare chance hit could be expected. Confidence in the airplane increased during the period of unobstructed flying to the point where aviators began to seek for themselves a means of interfering with the activities of hostile aircraft. Some pilots armed themselves with pistols, observers took along shot guns or rifles and all proceeded to fire at enemy flyers. As might be expected, little if any damage was done until some observer equipped himself with a ground machine gun and really went out for business. It necessarily followed that all airplanes were quickly equipped with machine guns and the actual offensive operations of the air began.

The first airplanes equipped were those carrying an observer, and he operated the gun. The speed of these airplanes was low as compared to the single seaters and as speed and maneuverability were of decided advantage in combat, it became imperative to equip the faster machines with these guns. In these airplanes the pilot had of course to operate the gun and since he could not point it and fly his airplane at the same time, it became necessary to fix the gun to the structure and direct it by maneuvering the airplane. In airplanes of the pusher type in which the propeller was behind the pilot, the gun could be mounted to shoot ahead without difficulty, but in the tractor type with the propeller directly in front, the gun had to be mounted on a tripod on top of the upper wing, so fixed that it would shoot over the propeller. This installation was used at first but was not readily accessible to the pilot, and was cumbersome and offered a decided air resistance in flight. It therefore became necessary to mount the guns where they would be accessible to the pilot and also out of the slipstream of the propeller. The most convenient place for this was over the motor either under or close to the cowling, but in such a position they must of necessity fire through the space swept by the propeller. With the blades of the propeller passing through the line of fire of each gun 3,000 times a minute and the gun firing at the rate of from 700 to 1000 rounds a minute, there was little time for a bullet to get by the propeller without striking it. The first installations provided no means for regulating the fire of the gun so it would function only when the propeller blades were out of the line of fire and as was to be expected many propellers were struck. Some blades were hit twelve times without breaking, but generally six or eight shots and sometimes even fewer were sufficient to cause rupture. Attempts to armor blades to prevent

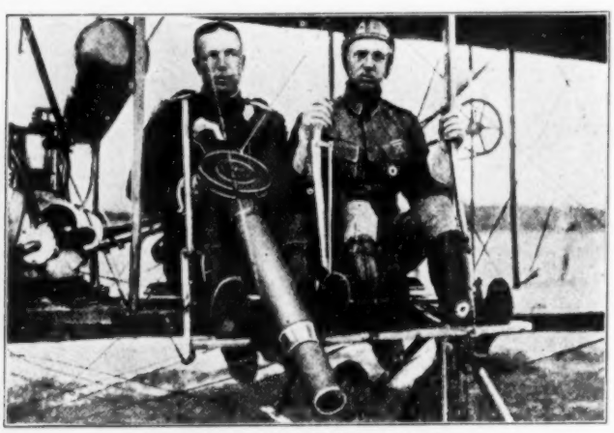
damage from the impact of bullets were not successful. Finally a device called a synchronizing gear was developed



Airplane Fully Equipped With Machine Guns

The two guns in the foreground are Lewis Aircraft Machine Guns mounted on a *tourelle* and are the free or observer's guns. They can be swung up and down and traversed around to permit of firing in all directions not obstructed by the airplane structure. The round magazines fitted on the tops of the guns carry the ammunition and when empty can be replaced by the observer. One of the two fixed or synchronized guns can be seen in front of the pilot's cockpit, mounted to fire over the motor and through the space swept by the propeller. The chutes leading down from the gun are passages through which belt links and empty cartridge cases are ejected so that they will fall clear of the airplane. The loaded belt is fed to the gun through a chute on the left side of the gun (not shown in picture). The Lewis Aircraft Gun mounted on the right side of the airplane is an extra gun carried for ground attack only and is not a part of the usual equipment. The muzzles of two guns can be seen indistinctly under the fuselage pointing to the rear. These guns are floor or tail guns used to cover the blind area (not covered by the observer's guns) under the tail of the machine and for ground attack. These two guns are additions to the standard equipment and are not used in all types of airplanes.

which restricted the firing of the gun to the time when the propeller blades were out of the line of fire. The gear is



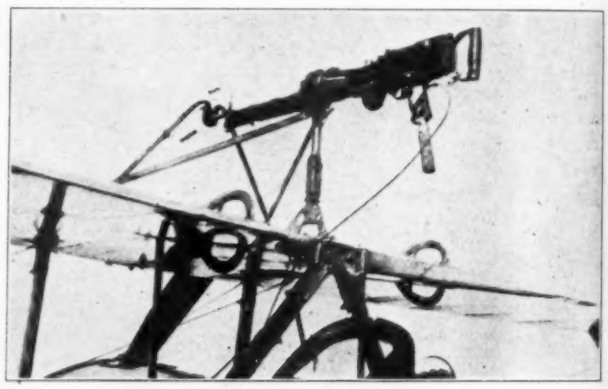
First Machine Gun Fired From Airplane

In June, 1912, at College Park, Md., a Lewis Ground Machine Gun was taken up in a Wright airplane and successfully fired by Col. Chandler, U. S. Army.

basically a cam mechanism interposed between the engine of the airplane and the firing mechanism of the gun, which operates the firing mechanism during certain parts of the cycle of the engine. The motion of the cam is transmitted to the gun by mechanical, hydraulic or electrical systems which can be thrown in or out of action by the pilot operating a trigger connected to the system and located on the control stick of the airplane. Thus a fixed or synchronized gun became a part of the fighting equipment of the airplane.

The observer continued to use a gun which was so mounted that it could be directed at will through a field of fire not obstructed by the airplane itself and this type of gun was appropriately termed a free gun.

At first all the guns used in airplanes were ground machine guns, for the reason that they were the only type available. Various modifications were made to adapt them to air use such as removing the radiator and radiator casing from the Lewis gun and making ventilating cuts in the water jackets of the other types. This procedure was feasible, for the guns did not require any special cooling devices in the air as they were fired only in bursts of short duration and the continued flow of air past them assisted in keeping them cool. Later, guns developed strictly for aircraft use were much refined over the modified gun. They were reduced materially in weight and their rate of fire was greatly increased. One of our standard guns weighed only 23½ pounds and fired as high as 1,000 shots a minute, whereas the ground gun of the same caliber weighed 36



Original Mounting of Fixed Gun

The gun was mounted on the top of the upper wing so that the bullets would pass over the propeller. It was fired by a control leading to the pilot's cockpit. In this position the gun was inaccessible and jams were difficult to clear. The mounting and gun offered considerable resistance to the passage of the airplane through the air. With the development of the synchronizing gear this mounting was abandoned and fixed guns were mounted close to or under the cowling.

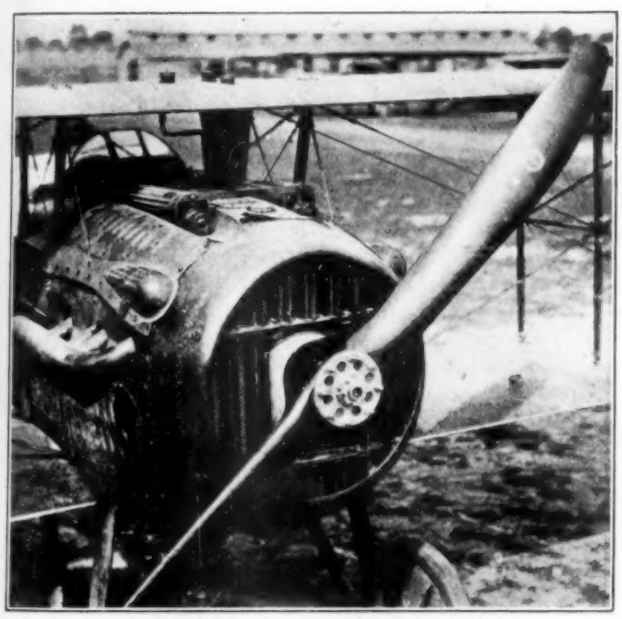
pounds and had a maximum rate of fire of only 600 shots a minute. It is interesting to note that a type gun developed in this country and now issued to our service was reduced in weight and increased in rate of fire to the point where it is capable of delivering 3 horsepower for each pound of its weight. This when compared to the Liberty Motor, which requires two pounds to develop one horsepower, indicates the remarkable refinement reached in the aircraft weapon.

The development of the aircraft gun brought about the need for certain accessories. These included metallic links which replaced the web belt of the ground gun for holding the cartridges as they were fed into the gun and which as the cartridges were extracted disintegrated and fell from the gun. Special sights for directing the fire of the gun and special mounts were devised both for fixed and free guns. As the guns were required to fire at extreme altitudes where the tempereature is very low, electric heaters were designed to keep the oil used to lubricate the action from becoming gummed or frozen.

The use of these guns brought out the need for several

different types of ammunition. Ground guns had been using the ordinary ball cartridges as well as a limited quantity of armor-piercing ammunition, both of which were immediately available for aircraft use. The airplane was such a fragile target that the ordinary ball ammunition was very effective, but as the war progressed and light armor was added as a protection to the men and to particularly vulnerable parts of the airplane the ball ammunition became correspondingly ineffective and the armor-piercing bullet was needed to reach the protected parts and cause damage. It was recognized that the airplane with its gasoline tank and general inflammable structure was particularly vulnerable to fire and this led to the development of incendiary ammunition. This ammunition proved effective particularly from a standpoint of morale, as all pilots and observers had a horror of being brought down in flames. Tracer bullets were also developed to assist the gunner in sighting. These gave streaks of light as they left the gun and traced their paths as they traveled through the air, indicating to the gunner where his bullets were going.

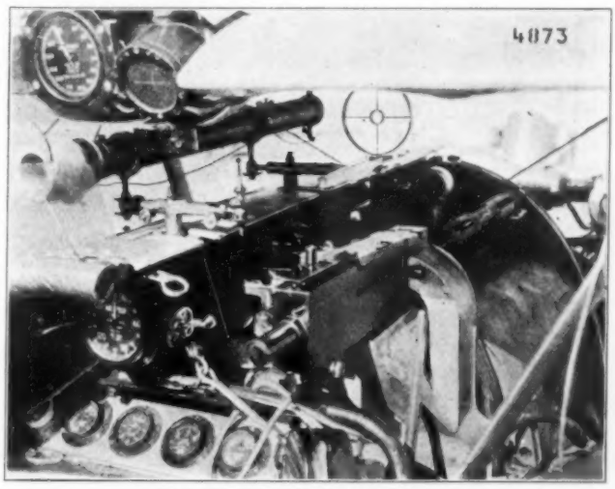
While the attack of airplanes was receiving so much attention, other types of aircraft, the dirigible and balloon,



Synchronized Mount for Two Vickers Aircraft Guns

The guns are so mounted on a pursuit airplane as to fire through the field swept by the propeller. A synchronizing gear controls their fire so that the propeller will not be struck. The guns are ground guns converted for aircraft use and show the water jacket opened up to permit the flow of air around the barrel for cooling. Modern aircraft guns are much lighter and less bulky and permit of even more compactness in mounting than shown here.

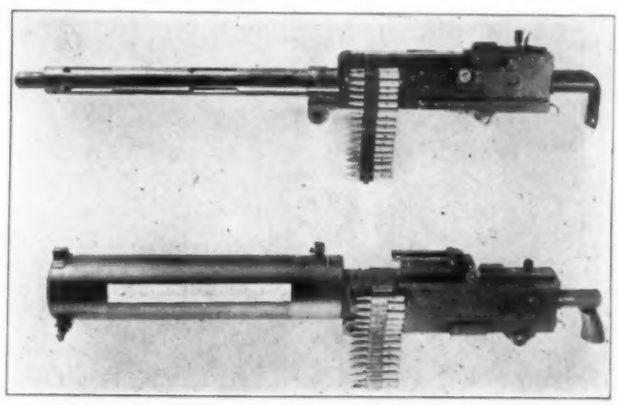
were not being forgotten in the offensive operations of the air. The Zeppelin raids over London and their use in reconnaissance over the North Sea demonstrated to the world the military value of the dirigible, but there are probably few people who really appreciate the important part played by observation balloons in the war. These observation balloons were held in position by cables leading from the ground and from each balloon was suspended a basket, carrying observers, who watched the effect of artillery fire and directed it from their platform in the sky or observed the various phases in an engagement, reporting the changing position of the lines and other military features apparent from that high vantage point. It was quite important, therefore, that an enemy's activities with the balloon and dirigible should, if possible, be limited. Both of these types of aircraft had one thing in common, an envelope filled with hydrogen gas which was their only means of support. Hydrogen can be easily ignited, and if mixed with the proper amount of air will



Modern Synchronized Mounting

The gun is under the cowling and being out of the windstream from the propeller offers no resistance to the flight of the airplane through the air. The gun is light and compact to permit of mounting in the small space allowed. With all the instruments and other things demanding the attention of the pilot, the gun can receive little if any attention, and as the pilot must depend upon it for success, it must function reliably. Telescopic and ring and bead sights for aiming are shown mounted between the cowling and wing.

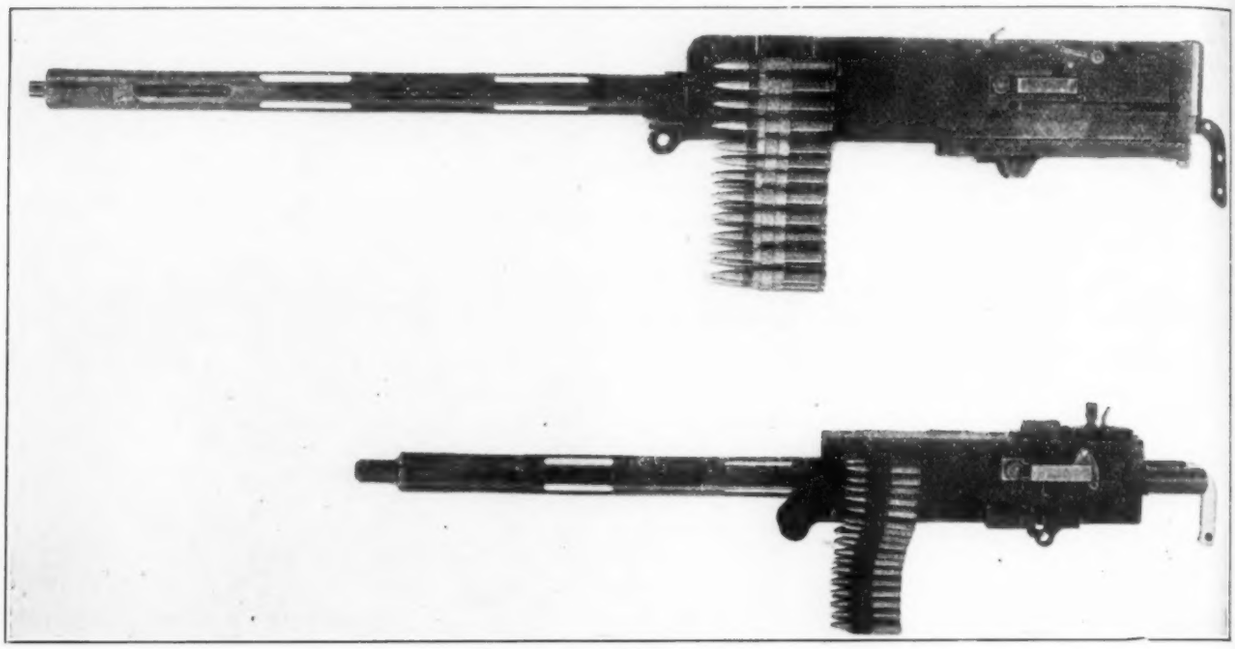
explode when a spark or flame is brought in contact with it. The best means of attacking the balloon or dirigible, therefore, was with incendiary ammunition, but with the .30 caliber machine guns it was found that, for some reason, even though the envelope of the balloon was hit with incendiary bullets, it would not always be ignited. A larger bullet to produce a greater incendiary effect seemed to be required and the first step in the increase in calibers for guns of the air was taken when a gun 11 mm. in caliber was developed for the special purpose of attacking this type of target. The result was extremely satisfactory, as the increase in caliber enabled the bullet to carry enough incendiary material to assure ignition when hits were made. At this stage, however, the increase in caliber of the gun



The Aircraft and Ground .30 Caliber Browning Machine Guns

The aircraft gun is lighter and fires at a higher rate of speed than the ground gun.

was obtained at the expense of velocity. The gun could not be used effectively against airplanes, as high velocities were required to insure hits and to penetrate the protected parts of the structure. The gun was, therefore, a special



Browning Aircraft Machine Guns

Upper: .50-caliber. Lower: .30 caliber. These are standard types of synchronized aircraft guns in our Air Service. The modern aircraft weapon is compact, light and fires at a high rate of speed, giving high muzzle velocities.

purpose weapon to be used primarily against balloons and dirigibles.

When the advance in development of aircraft permitted the carrying of armor and the use of metal bracings and coverings, it was found that even the armor-piercing ammunition of the .30 caliber aircraft machine gun was being reduced in effectiveness. It lacked the power to always pierce the armor, and if it passed through a metal strut or brace in the structure of the airplane it would not weaken it to the breaking point. This naturally pointed to the need for a larger caliber gun. It was recognized that such a gun must be mounted in pursuit airplanes on which air supremacy depended, but since these rapid single seater fighters which had to climb to great altitudes could not carry very heavy weights, the caliber of the gun which could be used was limited. The 11 mm. gun developed for attacking balloons and dirigibles was not powerful enough, but it was felt that if a gun of this size could be designed to give higher velocities, it would be just the weapon required. The development of such a gun was undertaken, but a satisfactory one was not produced during the war. Initial satisfactory tests of a .50 caliber aircraft machine gun have recently been held in this country, and there is every indication that this super-machine gun will be used on all aircraft in future battles in the air.

[Part II will be published in a later number of Army Ordnance.]

Spades and Floats for Mobile Gun Carriages

By

D. A. GURNEY

Member A. O. A.

IN the design of a mobile gun carriage, it is necessary to so design the rear end of the trail that movement of the carriage to the rear will be prevented under all conditions when firing on ordinary soil. That part of the trail end which prevents the carriage from moving to the rear is called the spade, and the portion which tends to prevent burying in the ground is called the float.

For centuries the gun carriage was a rigid construction, being merely a wheeled support for a gun, and the only resistance offered to the recoil of the gun was that afforded by the inertia of the carriage itself. Such a carriage has to be run up by hand after each round, and this operation in connection with that of resetting the trail in sighting was the most laborious and the one requiring the longest time between shots. It is interesting to note that this operation was not required by field matériel existing about 1400 A. D. The pieces at that time were of low power and weighed, generally speaking, about 200 times the weight of the projectile. The carriages were constructed of wood with very little, if any, ironwork. In view of the low velocity of the projectile and the relatively great weight of the gun and carriage, it was possible and customary to keep the carriage from recoiling by driving stakes into the ground at the end of the trail, the gun having a considerable motion in azimuth on the carriage. Increase in the power of these field guns kept pace with the knowledge of war matériel and progress in the arts, and the limit of strength of the carriage with no recoil was soon reached, after which it was necessary to omit the traversing arrangement, making them more rigid, and to permit them to recoil on the ground.

This form of rigid carriage was used exclusively until about 1890, at which time the increasing power of the gun gave rise to such extreme recoil of the carriage that some system of brake to the carriage became necessary in order to reduce the labor of running up. This took the form of either a hub, tire or drag shoe brake, and merely added the resistance of mechanical friction to that of the inertia of the carriage with a view to reducing the length of recoil.

The next advance in this direction was marked by the introduction of the spring spade. In this a spade attached to a helical spring was set under the carriage; on discharge the spade dug into the ground, compressing the spring as the carriage recoiled. The expansion of the spring ran the carriage up again without assistance from the gunners. This system is open to the objection that the gunners have

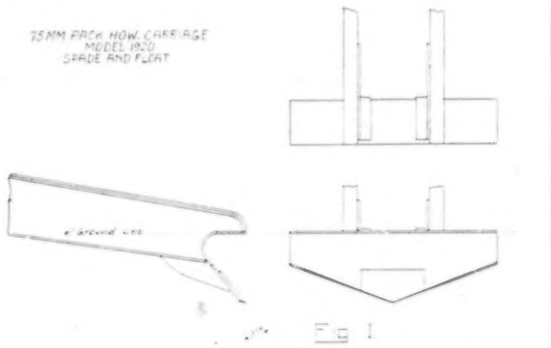


Fig 1

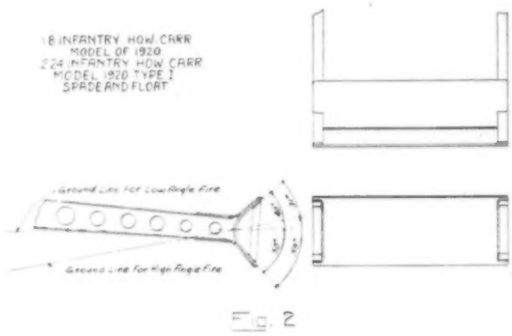


Fig. 2

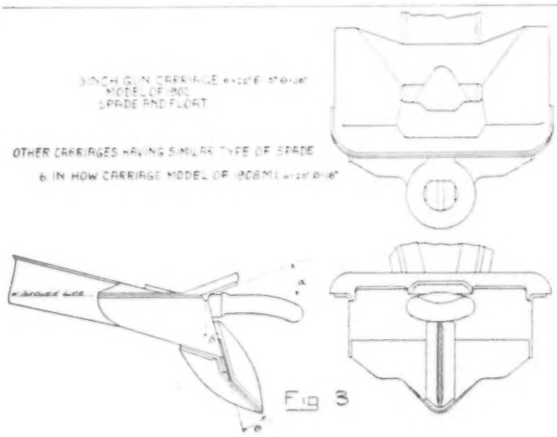


Fig 3

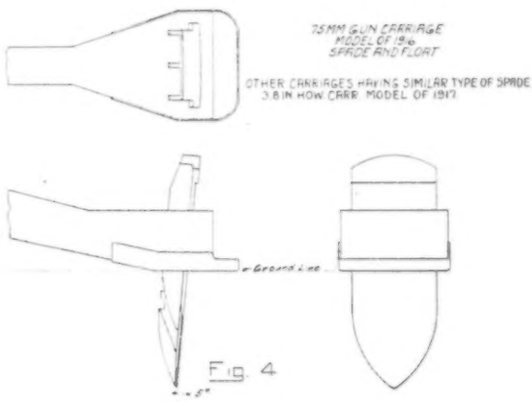


Fig. 4

to stand clear of the wheels on recoil, and the gun must be resighted after each round.

The latest development, the long recoil gun carriage designed to provide a steady non-recoiling platform, permits the anchoring of the carriage to the ground, so that it is not disturbed in firing, and consequently greatly increases the rapidity of fire. A large number of different designs of spades and floats for anchoring the gun carriage to the ground are employed on mobile gun carriages in this and other countries, and it cannot be said that any one type will give universal satisfaction under all conditions. For light artillery it is customary to so design the spade that it will dig itself in when the piece is fired. For the heavier corps and army artillery it is customary to dig a hole for the spade, so that it will be partially or completely seated before firing. The floats are ordinarily designed to prevent excessive burying of the trail when the gun is fired on soft ground.

Several different types of spades, some of which are in service use and others of which are only experimental, are shown in the accompanying figures, Nos. 1 to 11.

Figure 1 shows the type used on the 75 mm. Pack Howitzer Carriage, M. 1920. This spade has been subjected to considerable firing at Rock Island Arsenal and at Aberdeen, and it is found that it has a great tendency to dig out in firing. This is thought to be due partly to the shape of the float and also to that portion of the trail flasks in front of the spade which comes in contact with the ground before the spade becomes thoroughly seated. This construction is now being modified for further test.

Figure 2 shows a unique type of spade and float used on the experimental 1.8-inch and 2.24-inch Infantry Howitzer Carriage, M. 1920. This spade and float is designed so that it will hold equally well when the carriage is in either the low angle or the high angle position. This carriage has a cranked axle, and when low angle of fire is used, the trail is placed in position so that the cranks extend downward from the wheel hubs, thus lowering the howitzer and giving good stability. In order to increase the ground clearance at high angle of fire, the trail is reversed so that the cranks extend upward from the axle. This type of spade and float has not had sufficient test to determine whether it will be satisfactory.

Figure 3 shows the type of spade used on the 3-inch Gun Carriage, M. 1902. This type was arrived at experimentally and has given general satisfaction. The type of spade and float originally used on this carriage was similar to that shown in Figure 1. The float, instead of being in rear of the spade, was built out on the sides. It was found that this spade would not dig in properly, and that the float was ineffective, the trail tending to bury itself, sometimes to a depth of two feet. The difficulty in digging was corrected by changing the shape of the spade point, and the float area was extended in rear of the spade, thus preventing the burying action.

Figure 4 shows the type used on the 75 mm. Gun Carriage, M. 1916. This type of spade and float is also used on the Italian Deport. The spade is movable in the rear end of the trail, and is seated by driving with a heavy

75 MM GUN CARRIAGE
MODEL OF 1897
SPADE AND FLOAT

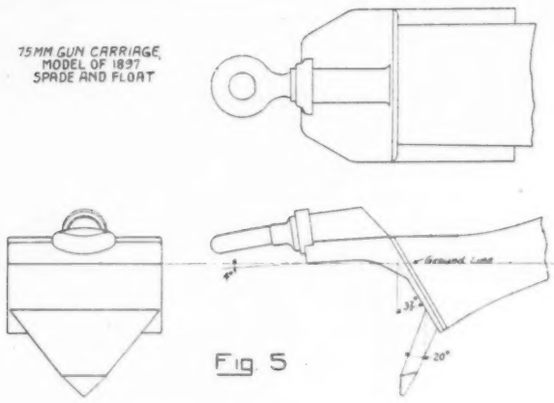


Fig. 5

75 MM GUN CARRIAGE MODEL OF 1920.
105 MM HOWITZER CARRIAGE MODEL OF 1920.
SPADE AND FLOAT

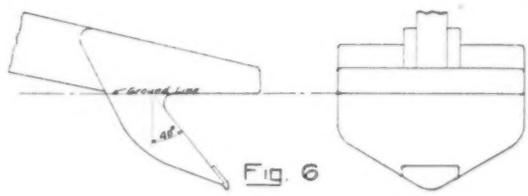


Fig. 6

75 MM GUN CARRIAGE MODEL OF 1921.
105 MM HOWITZER CARRIAGE MODEL OF 1921
SPADE AND FLOAT

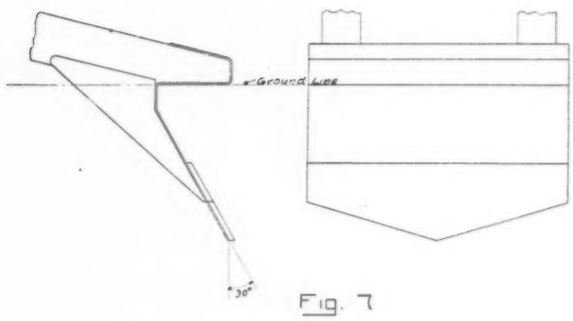
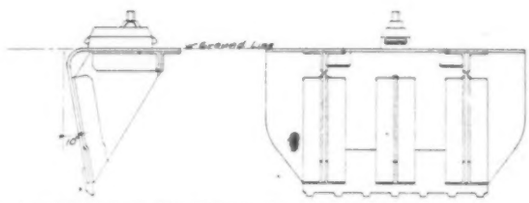


Fig. 7

4.7 IN GUN CARRIAGE MODEL OF 1920
155 MM HOWITZER CARRIAGE MODEL OF 1920
SOFT GROUND SPADE AND FLOAT



OTHER CARRIAGES HAVING SIMILAR TYPE OF SPADE
155 MM GUN CARRIAGE MODEL OF 1918
155 MM GUN CARRIAGE MODEL OF 1920
8 IN HOW CARRIAGE MODEL OF 1920
194 MM GUN CARRIAGE MODEL OF 1919.

Fig. 8

4.7 IN GUN CARRIAGE MODEL OF 1920 $\alpha = 10°$
155 MM HOWITZER CARRIAGE MODEL OF 1920 $\alpha = 10°$
HARD GROUND SPADE AND FLOAT

OTHER CARRIAGES HAVING SIMILAR TYPE OF SPADE
8 IN HOW CARRIAGE MK. VI $\alpha = 50°$
8 IN HOW CARRIAGE MK. VII $\alpha = 50°$

Fig. 9

155 MM HOWITZER CARRIAGE
MODEL OF 1918
SPADE AND FLOAT

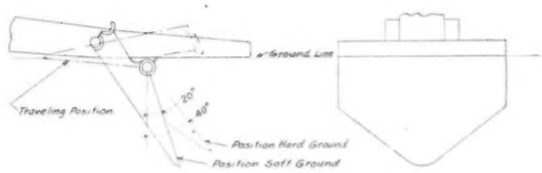


Fig. 10

4.7 IN GUN CARRIAGE
MODEL OF 1906
SPADE AND FLOAT

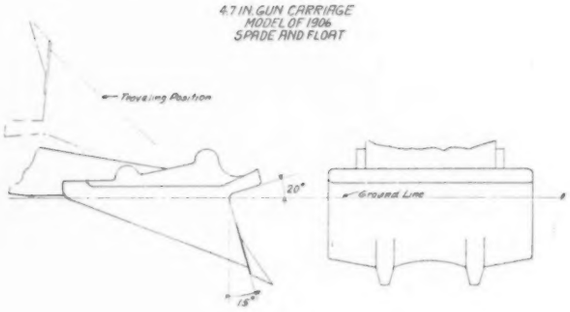
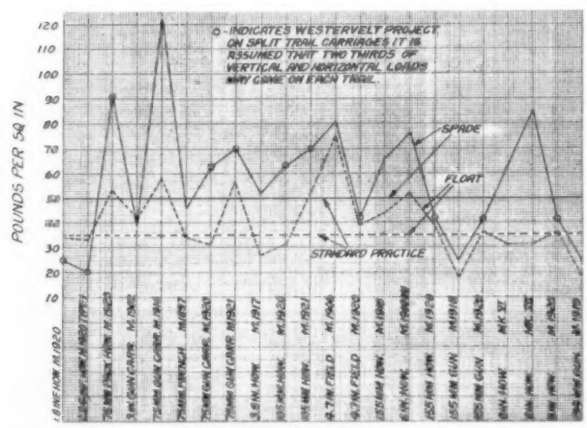


Fig 11



SPADE AND FLOAT LOADS
Fig 12

sledge. The advantage of this type is that it is not necessary to fire a round in order to seat the spade, and on suitable soil there is little or no recoil or counter recoil of the carriage upon the ground. The objection to this type of spade is that considerable time is necessary to get into action, and on hard ground it is difficult and sometimes impossible to properly seat the spade.

Figure 5 shows the type of spade and float used on the French 75 mm. Gun Carriage, M. 1897. This type is very satisfactory, but is of considerable heavier construction than other spades. The spade proper is made of a heavy forging, which is secured to the rear end of the trail with a relatively heavy construction. For moderately soft ground the float is perhaps too small, as it has a tendency to bury itself.

Figure 6 shows the type of spade used on the new 75 mm. and 105 mm. Howitzer Split Trail Carriage, M. 1920. This spade has been subjected to considerable firing tests at Rock Island Arsenal and at Aberdeen, and thus far has given good satisfaction.

Figure 7 shows the type of spade used on the 75 mm. Gun and 105 mm. Howitzer Box Trail Carriages, M. 1921. This spade has not yet been subjected to firing test.

Figure 8 shows the type of spade used on the 155 mm. Gun Carriage, M. 1918 (Filloux) for firing on soft ground. This spade is removable, being attached to the rear end of the trail by means of swing bolts and nuts. A similar design is being used on the new carriages for corps and army artillery. It is intended that a hole be dug in the ground for seating the spade before firing, although it is hoped that in the case of at least the new corps artillery, this may not be necessary, and it may be found practicable to fix the spade to its seat.

Figure 9 shows the type of hard ground spade used on the same carriages as in figure 8.

Figure 10 shows the type of spade used on the 155 mm. Howitzer Carriage, M. 1918 (Schneider). This spade can be rotated about the pivot on the lower flange of the trail so as to occupy three different positions: first, folded up in traveling position; second, in the soft ground position; and third, in the hard ground position. This spade is fairly satisfactory, although the spade area for soft ground is insufficient.

Figure 11 shows the type of spade used on the 4.7-inch Gun Carriage, M. 1906. The same difficulties were found with the original design of this spade as were found with that of the 3-inch Gun Carriage, M. 1902 (Fig. 3) and the design has been changed along similar lines. This spade can be folded over on top of the trail for traveling.

Attached hereto is a table showing a comparison of spade and float pressures found on various mobile artillery carriages. For split trail carriages, this table has been made up on the assumption that two-thirds of the vertical and horizontal loads may come on one trail.

The spade and float loads in pounds per square inch for the various carriages listed in the table are shown plotted to scale on the accompanying curves. A tentative figure to be used in the design of spade and float areas is 50 pounds per square inch for spades and 35 pounds per square inch for floats. These figures are indicated by straight lines on the curve sheet, but are not to be considered final as the service to which the matériel is put and the degree of stability required will determine to a great extent what spade and float pressures are permissible.

COMPARISON OF MOBILE GUN CARRIAGE SPADES AND FLOATS.

April 15. BPJr.

Name of Carriage	Total Spade-load Lbs.	Load on One Spade Lbs.	Area of Spade Sq. Ins.	Spade-load Lbs. per Sq. In.	Type of Spade	Total Float-load Lbs.	Load on One Float Lbs.	Area of Float Sq. Ins.	Float-load Lbs. per Sq. In.	Type of Float
75 MM. Pack How.....M.-1920	7,100	.....	78	91	Fixed	2,850	.....	54	53	Fixed
3 In. Gun Carr.....M.-1920	5,000	.....	130	39	Fixed	2,405	.....	57	42	Fixed
75 MM. Gun Carr.....M.-1916	13,300	8,900	73	122	Driven	5,500	3,650	63	58	Fixed*
75 MM. French.....M.-1897	5,200	.....	114	46	Fixed	2,657	.....	78	34	Fixed
75 MM. Gun Carr.....M.-1920	12,300	8,200	130	63	Fixed	7,500	5,000	160	31	Fixed*
75 MM. Gun Carr.....M.-1921	15,000	.....	215	70	Fixed	7,000	.....	123	57	Fixed
3.8 In. How.....M.-1917	9,000	6,000	116	52	Driven	4,648	3,100	111	27	Driven*
105 MM. How.....M.-1920	12,300	8,200	130	63	Fixed	7,500	5,000	160	31	Fixed*
105 MM. How.....M.-1921	15,230	.....	220	70	Fixed	6,600	.....	126	52	Fixed
4.7 In. Field.....M.-1906	16,160	.....	200	81	Swing	8,133	.....	112	75	Swing
4.7 In. Field.....M.-1920	49,000	32,700	788	42	Detach	32,000	21,500	556	39	Detach*
155 MM. How.....M.-1918	39,000	.....	590	66	Fold	29,000	.....	660	44	Fixed
6 In. How.....M.-1908 MI	27,650	.....	363	76	Fixed	8,600	.....	165	52	Fixed
155 MM. How.....M.-1920	49,000	32,700	788	42	Detach	32,000	21,500	556	39	Detach*
155 MM. Gun.....M.-1918	41,000	27,300	1,100	25	Detach	36,000	24,000	1,367	18	Detach*
155 MM. Gun.....M.-1920	122,000	81,500	2,000	41	Detach	87,000	58,000	1,620	36	Detach*
8 In. How.....MK VI	57,500	.....	910	63	Detach	20,000	.....	650	31	Detach
8 In. How.....MK VII	77,500	.....	910	85	Detach	20,000	.....	650	31	Detach
8 In. How.....M.-1920	122,000	81,500	2,000	41	Detach	87,000	58,000	1,620	36	Detach*
194 MM. Gun.....M.-1919	41,000	27,300	1,100	25	Detach	36,000	24,000	1,367	18	Detach*
2.24 Inf. How...M.-1920 Type I	1,946	.....	100	20	Fixed	987	.....	30	33	Fixed
1.8 Inf. How.....M.-1920	2,468	.....	100	25	Fixed	1,029	.....	30	34	Fixed

NOTE: * Indicate split trail carriages—assumed that ⅔ vertical and horizontal loads will come on one trail.

"Harmless" Ammunition.—Ordnance Department has recently completed experiments with what might be called "harmless ammunition". In their effort to economize, the Army ammunition authorities have made up a lot of ammunition that looks real and appears in every way similar to live material but lacks the explosive element. This line of imitation material is marked with a special blue color to show the initiated that it is not the real article. It is used just like the real ammunition even the explosion being simulated.

As an example, the new practice hand grenade—instead of containing the deadly TNT, is loaded with sawdust, powdered chalk, or pumice stone. When thrown in the usual way this grenade, instead of bursting into a hundred flying fragments, explodes with a modified pop and displays a large cloud of white smoke. After the smoke has cleared away, however, the whole grenade will be found lying on the ground in perfectly good condition for reloading and reuse.

In the same way the Department has perfected an imitation trench mortar shell. In a picture this shell could not be distinguished from the live article, but a color photo would show it to have the distinctive blue color to reassure the user that it is non-explosive. This ammunition is assembled and fired from the Trench Mortar exactly as high explosive ammunition. But there is no danger at the target except in case of a direct hit, for when it explodes it is all noise and smoke with no fragments at all. The recovered shell may be used over and over again.

Practice ammunition of this sort will be issued to simulate the action of all kinds of grenades, airplane drop bombs and small caliber artillery shell. By issue of this ammunition, together with simple instructions on how to reload it, the Ordnance Department will effect a considerable saving in time of peace as well as in training camps in event of war.

Requisites for Military Small Arms

By

J. C. GRAY

THE War Department is at all times interested in the progress that is being made in the design and manufacture of small arms and machine guns. There are presented for consideration from time to time suggestions of inventors along these lines. In many cases these suggestions disclose the fact that the inventor has little or no knowledge of the requisites for a satisfactory military arm. With a view to informing those who may be interested in pursuing this line of invention, a summation of the characteristics required in the various military arms will be made in the following pages.

Infantry armament in general comprises the shoulder rifle, the pistol and the machine gun.

Any military arm must be safe. Not only mechanically safe, but "fool-proof." This is perhaps the first requirement of any arm, regardless of whether it be a pistol or a cannon.

The next requirement of importance is that of sturdiness, ability to withstand abuse and rough usage. The arm must be able to endure all the severe tests to which a military arm may be subjected.

Simplicity of design and ease of manufacture are also important in the consideration of the value of any weapon to the Army.

Other requirements include reliability of functioning under all circumstances, the ability to withstand dust and rust and the stresses that may arise due to defective ammunition, and capacity for the delivery of rapid and accurate fire.

Weapons should be of length, weight and caliber well within the limits of portability, as it is of prime importance that they be easily carried and transported. There should be provision for the use of a satisfactory type of sight, capable of rapid and accurate adjustment, and, in the case of the rifle, this should be on the receiver. The replacement of broken or worn parts should be practicable in the field and therefore it should be possible to dismount and reassemble the weapon with few or no special tools.

The hand gun, pistol or revolver, is distinctly an American weapon in invention, development and service. In the evolution that is constantly taking place, the revolver has been largely superseded by the automatic pistol.

The Army is fortunate in having a service arm that is today believed to be equal to any and perhaps superior to all the weapons of this type in use elsewhere for similar purposes. It is thought unlikely that any material change will be made in the pistol for many years.

The specifications which were used at the time the service pistol was adopted are given in order that some estimate may be made of the characteristics of a satisfactory military hand-gun, as follows:

(a) The caliber should not be less than .45.
(b) The magazine should hold not less than 6 cartridges.
(c) The weight of the bullet should be not less than 230 grains, initial velocity not less than 800 f. s.
(d) Trigger pull not less than 6 pounds.
(e) A simple and durable mechanism with as few parts as possible, capable of being readily dismounted and assembled, using as few tools as possible.
(f) The number of springs, screws and pins should be reduced to a minimum, particularly in case of flat springs.
(g) As compact a magazine as possible, and of a shape adapted to carry in a holster.
(h) Adapted for use as a short range hand weapon and not a carbine.
(i) The breech to be closed and locked before the firing pin can reach the primer.
(j) An automatic safety so the pistol may be carried cocked and with the cartridge in the bore without danger and be ready to fire the first shot without any other action than pulling the trigger.
(k) Vertical, in preference to side, ejection of the cartridge case.
(l) Certainty of action in automatic loading and ejection.
(m) Comparatively easy action in ejecting by hand in case of misfire.
(n) Automatic indication that the arm is loaded.
(o) Automatic indication that the last cartridge has been fired from the arm.
(p) Good balance, and should have the grip adapted to the hand.
(q) A form of magazine catch that can be easily operated by the pistol hand and which allows the magazine to drop out.
(r) Such design that no special tools are required for dismounting or assembling
(s) Easy replacement of parts.
(t) Parts riveted together or permanently joined are objectionable.
(u) Loading by box magazine and not by clip.
(v) An automatic indication of the number of cartridges in the magazine.
(w) The magazine to be so arranged as to prevent the entrance of dust, etc.
(x) A position of the center of gravity as near as practicable to the axis of the bore.
(y) A bolt securely locked to the barrel until the bullet has left the bore.
(z) The bolt in one piece, rather than with a separate head.

Regarding the shoulder rifle, it is believed that today the Army is in possession of as satisfactory a hand-functioned weapon as can be developed. Its characteristics are in general well known and the weapon meets with all of the requirements as stated in the preliminary paragraphs. The manufacturing facilities available and the number of rifles on hand may almost be considered, under the circumstances, to preclude the possibility of adopting any radical change in a small arm of this type, except it be in the form of a semi-automatic weapon.

Practically all the interest in the development of small arms is concentrated on the problem of a semi-automatic rifle. Such an arm should, in general, have characteristics as follows:

It must be of a self-loading type, adapted to function with cartridges not less than .25 caliber or greater than .30 caliber, of good military characteristics and preferably to fire the U. S. cartridge, Caliber .30, Model of 1906. It must be simple and rigid in construction and easy of manufacture. It should require but little more attention than the service rifle when placed in the hands of the average soldier. It should be simple, strong and compact. Weights should be well balanced and so placed that necessary

strength is given to components as required. Ease of manufacture should be a guiding factor in preparing the design.

The mechanism must be well protected from the entrance of sand, rain or dirt and should not be liable to derangements due to long wear and tear, exposure to dampness, etc.

Components of the mechanism should be the fewest possible consistent with ease of manufacture and the proper functioning of the weapon. Parts requiring constant cleaning or which may require replacement should be so designed as to be easily dismounted by the use of not more than one small tool, and preferably by the use of the service cartridge.

The magazine should be fed from clips. The breech mechanism should be such as to preclude the possibility of injury to the firer due to premature unlocking. It is preferable that the bolt, or block, should be positively locked to the barrel at the moment of firing.

The capacity of the magazine should not be less than five rounds. Firing mechanism should be so designed that the firing pin is controlled by the trigger and sear direct. That is, the bolt mechanism should move forward to the firing position with the firing pin under control of the trigger and sear mechanism, so that the cartridge is not ignited until the trigger is pulled to release the firing pin. The bolt, or block, should remain open when the last cartridge in the magazine has been fired.

The trigger pull should not be less than three or more than five pounds. The trigger action should be similar to that of the present service rifle, that is to say, it should have at first a light pull, after which there should be no appreciable backward motion until the sear is released. An efficient safety or locking device should be provided, permitting the rifle to be carried cocked and with the cartridge in the chamber without danger. The rifle should remain cocked and ready for firing when the safety device is unlocked.

The weight, with magazine empty and without bayonet, should be a minimum for proper functioning and in no case for a semi-automatic shoulder rifle should it exceed ten pounds.

The rifle should be so designed as to give good balance and be adapted to shoulder firing, and for the use of the bayonet. In general appearance and outline, the gun should be as nearly as possible the same as the U. S. Rifle, Caliber .30, Model of 1903. It should be strictly semi-automatic, that is, a self-loading type, and not to function as an automatic rifle.

The accuracy of the rifle should be comparable to that of the present service shoulder rifle. The stock should be so designed, if practicable, as to allow ventilation of the gun without charring or overheating the wood, and it will be desirable that an inner lining be provided to insure against charring.

The foregoing specifications cover the requirements of a semi-automatic shoulder rifle and it may be said that while progress has been made in the investigation of this type, up to this time a satisfactory military weapon having these characteristics has not been developed.

Regarding machine guns, much that has been said might well be repeated. The features of lightness, compactness and safety from hangfires should be considered in such a design. A machine gun should be susceptible of delivering a high rate of fire, it should be simple in construction and easily operated, not likely to get out of order, the loading should be convenient and the magazines, or other means of supply of cartridges, such as belts, should preferably be such as to permit of uninterrupted bursts of at least 250 rounds. The loading mechanism should be simple and well balanced, and the center of gravity should be on the center line of bore, if practicable. The time required for loading belts or magazines should be a minimum.

Concerning the matter of caliber, the question of the wound produced by any bullet, and whether it will compel a man, when fairly struck, to leave the line of battle must have an important influence in deciding upon the minimum caliber adapted to warfare, it being best to use a bullet that will not be readily deformed and of such caliber and weight as to be sufficient to produce serious shock when penetrating the body. Our present adopted caliber is .30 inch and the bullet weighs 150 grains. The caliber of the service pistol is .45, and the bullet weighs 230 grains.

The requirements for the caliber for the rifle and pistol are very different. With the rifle, wounds will be given at long ranges and it is only necessary that the wound should be sufficiently shocking to prevent the wounded soldier holding out long enough to reach the point of attack. With the pistol, the case is otherwise. The wounds will generally be given at distances of 10 to 50 feet and, however serious, the soldier might in some instances reach the point of attack unless there is sufficient shock from the bullet to stop him.

It is the purpose of the War Department to establish regulations for an expert examination and test of the improvements which may be presented from time to time to such an extent as will determine the merits of the invention for military service by comparison of the arms submitted with those previously tested and at the same time assist inventors in developing their improvements and perfecting such as appear to be meritorious. Consideration will be given only to arms or improvements adapted for use in the military service and, unless otherwise authorized, to such as pertain to an arm of the present service caliber.

When a design for an arm or improvement is submitted which, upon examination, is considered as offering a reasonable hope of being developed into an arm presenting superior features to those in use or previously tested, then assistance may be furnished to the inventor by selling to him at cost price any completed parts of ammunition or arm made by the Government as he may desire, but the Government will not undertake the manufacture or repair of any arm or part thereof for private parties. Descriptions or drawings of models submitted for examination and patent specifications, if taken out, should be furnished in duplicate, one copy to be retained by the War Department.

When an arm ready for trial is presented by an inventor or his representative, it will be subjected to a critical examination regarding its merits and the report of the examiners, with recommendation thereon, will be considered. Accompanying this examination and for the purposes of the report, the arm will, in the discretion of the Department, be subjected to such firing tests as pertain to the ordinary conditions of the service. The arm will not, however, be subjected to firing test when careful consideration of the parts makes evident defects or weaknesses or features undesirable in a military arm.

Panoramic Sights

By

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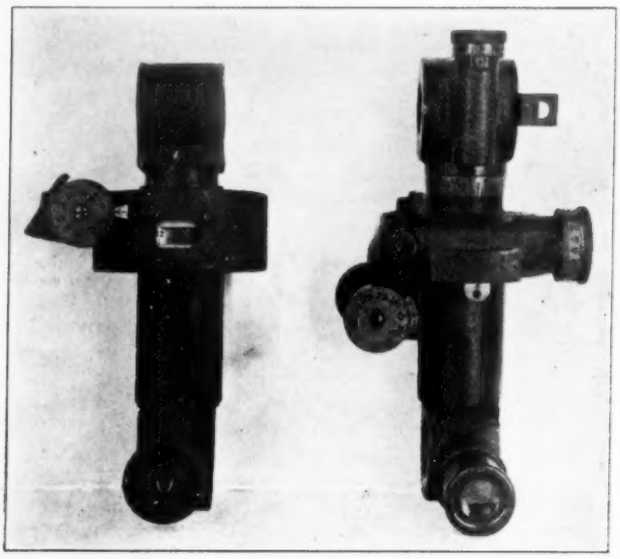
Member A. O. A.

THE panoramic sight is a vertical telescope of the periscopic type with an optical system of reflecting prisms and lenses so arranged that the gunner, with his eyes at the fixed eyepiece in a horizontal position, can bring into the field of view an object situated at any point in the horizontal plane passing through the telescope.



Panoramic Sights

Model of 1904 Model of 1915

This instrument is a comparatively modern development in devices of fire direction. Until the early part of the nineteenth century, the only means of sighting cannon was by looking along the gun toward the target and wedging the muzzle up or sliding the mount around until, in the judgment of the gunner, the cannon was correctly pointed. At the comparatively short effective range of these cannon, the error in sighting was not an important consideration. In fact, in the year 1801, it was suggested to Lord Nelson that some form of sighting apparatus should be furnished with his naval guns, but this he disapproved, giving as his opinion that the short ranges and point blank firing did not require any more accuracy than was obtained by the service method.

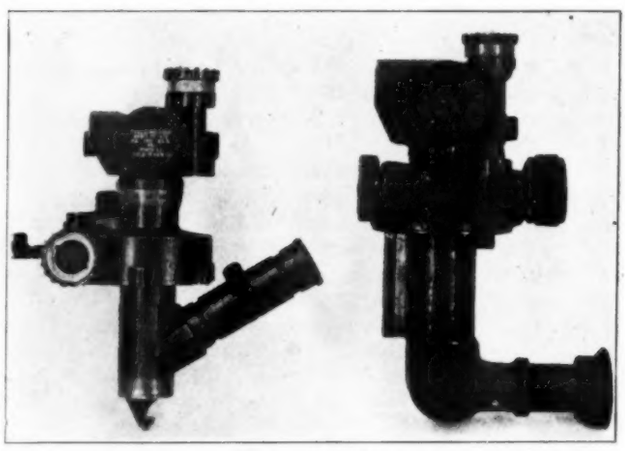
Fixed sights, integral with or fastened integrally to the guns, came into use shortly after Lord Nelson's adverse decision. These sights were, in most cases, just knobs or raised lines of metal on the gun castings themselves. Due allowance was made for the fact that the guns were thicker at the breech than at the muzzle, but further than this there is no record of other corrections.

The next advance in methods of sighting, the system of having one part of the sight fixed and the other movable by the gunner to an angle corresponding to the range of the target, is attributed to Colonel Jure, of the French Army. This system was not adopted until after the simple line of metal sights had been in use on both land and naval guns for some time. It was fully five hundred years after the first recorded use of cannon that accuracy in directing fire was considered of enough importance to warrant the development of gun sights. Then Colonel Jure's range calibrated sights came into general use.

From the short and now thought insignificant range obtained with these early guns, there has been great advancement in the art of gun making until the extended ranges of the present time are met with. One noticeable result of the advance is the change in the method of fire, the early types, except mortars, being fired directly at a visible target, while at present fire from a masked position to an invisible target is the rule for the majority of cases. This change necessitated accurate sighting apparatus and ease of setting the gun.

This improvement in the ranging qualities, accuracy and increase in rate of fire was the initial factor in the development of true sighting systems, those in which some form of telescope is used. All the announced improvements were either to facilitate the work of properly laying the gun, to insure the final setting to be as accurate as mechanism can be made to function, or to speed up the number of shots fired in an interval without lessening the accuracy of placement of these shots.

Elementary telescopic sights are recorded as having been used about 1857. These sights, however, gave very little success, due more probably to optical defects than to disadvantages in service use. A telescopic sight was used as regular equipment in the United States service in 1896, followed by other models in improvement of various de-



Panoramic Sights

Model of 1920 Model of 1917

tails up to the 1912 M1 sight, which is the most modern of this type.

These telescopic sights were, in general, Gallilean in type, with a suitable means of setting deflections and moving the optical center line of the sight to correspond.

They were, for the most part, free to move in elevation according to the position of the target.

A target, practically invisible to the unaided eye, becomes easily located by a telescope of even low power. A telescope satisfies the need of the gunner for vision to a longer range to correspond to the increased ranges of the guns.

The open, or line of metal sights, in most cases, requires that the gunner be able to see and distinguish three objects at the same time, all three at varying distances from his eye. First, he must see the rear sight, then the fore sight, and lastly, both sights must be lined up on the target. This naturally puts quite a strain on the gunner's eye. With a telescopic sight, the cross-hairs in the instrument defining the optical center-line of the telescope appear thrown out into the field of view and appear to be as distant as the target. There is no strain in the telescopic sight of the same nature as that occurring in the open sights.

The increased range of vision given to the gunner by the adoption of telescopic sights is due, of course, to the resolving power of the instrument.

While the straight-tubed telescopic sight was a great improvement over all previous sights, it was still lacking in several necessary details, which restricted its use for the prevailing indirect method of fire.

In firing indirectly, the target is invisible to the gunner at the sight. The target is, therefore, located in all particulars from an observing station to which it is visible. Then, a stake, called an aiming stake, is set up at some point visible to the gunner, and the location of the target is plotted from the known data with the aiming stake as origin. The sight is correctly set off in the deflection, and, by training the gun until the aiming stake is cut by the cross-hairs in the sight, the gun is pointed at the target. It is, therefore, sometimes convenient to have the aiming stake at various points around the gun, perhaps, at times, directly to the rear.

The straight telescopic sight could only be used with aiming stakes directly to the front, or within its deflection limits. A method was required which would allow the use of an aiming stake at any convenient point. The gunner's eye should be retained in the same position, if possible, for obvious reasons. Then, it should be possible for the gunner to look directly to his rear, without having his head in the way.

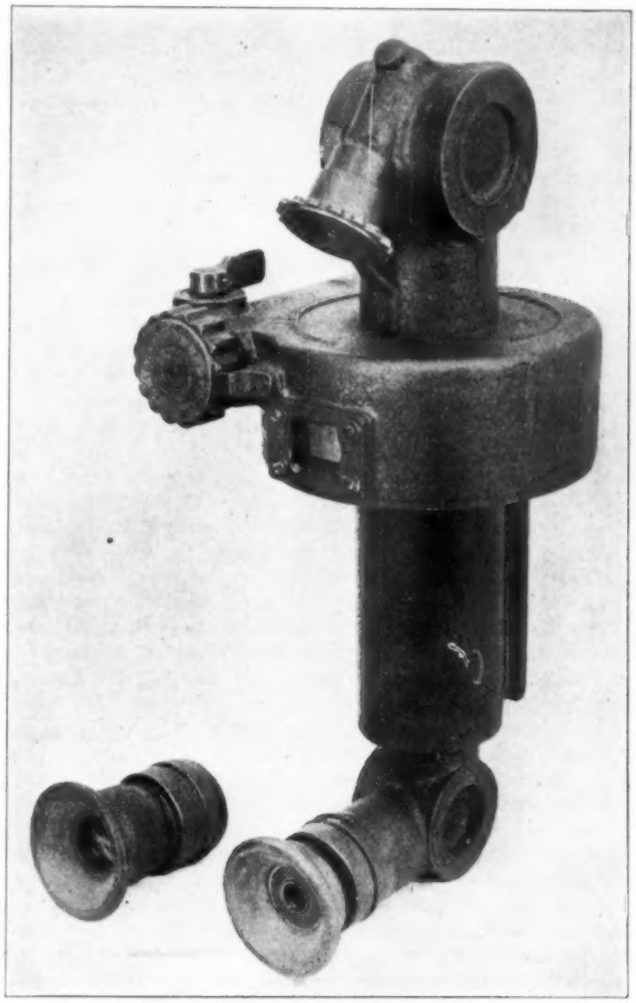
The periscopic form of telescopic sight fills the requirements, having its rotatable objective above the gunner's head and cap, affording a view around a complete circle. This feature gives a practically unlimited area for the setting up and use of aiming stakes, or of the use of favorably located natural aiming marks.

The panoramic sight, or, more properly, panoramic telescope, was the invention of Carl Paul Goerz, of Friedenau, Berlin. Application for United States patent was made by the inventor in August 4, 1902, the invention being of probably earlier date. The records show that the patent was not granted until March 14, 1905, nearly three years later, and after the instruments purchased from the inventor were already in the U. S. service.

On February 1, 1904, the Chief of Ordnance, U. S. Army, gave an order to the C. P. Goerz Optical Company, Berlin, for 125 panoramic sights, made up according to the company's own design. This was the initial order for sights, and manufacturing rights were obtained at the same time. This order of instruments was duly filled and shipped to this country after inspection by Captain, now Colonel J. W. Joyes.

On arrival in the United States, the instruments were given the name of "Panoramic Sights, Model of 1904." The manufacturers had called them "Panorama Telescopes". These sights, and in fact all 1904 sights, were very rugged in construction and many of them are in service today. The 1904 sight did not have the rotation of the objective head in elevation, but is otherwise, with the probable exception of the "T" slot fastening, as efficient as any type developed in later years.

There were some details of service requirements missing in the original design of sights, as well as some defects of



Panoramic Telescope for Railway Mounts

construction and assembling. The sights furnished by the Goerz Company had no provision for illuminating the cross-hairs, or reticule, so that the instruments could be used to direct fire at night. This defect was remedied in those instruments made in this country by putting a slot into the barrel of the sight opposite the reticule and inserting a glass plate in the slot. A pocket flashlight was held near this opening, showing up the cross-hairs as illuminated lines on the darkened field. Then the azimuth indices on the first order were painted on a lacquer base. This allowed for no real adjustment, once the index was painted on. In the later instruments, the index was cut into an adjustable plate, and the device adjusted after assembly.

It was noted during service and laboratory tests that the "T" shank, the element fastening the sight to the mounting, was not uniform in its entire length. The optics were

not properly focused. This defect is remedied by test and adjustments, provided the various lenses are capable of adjustment in their cells. The cross-lines on the reticules, determining the optical center-line of the instrument, were not at right angles to each other, nor were they horizontal and vertical. The line of sight did not swing true when the sights were turned in azimuth. All of the above errors were corrected by the engineers at Frankford Arsenal before the instruments were issued to the service.

The first artillery material to be equipped with the new panoramic sights was the 3 inch gun, model of 1902. While some of the instruments were in the field, others had been sent to various testing agencies, the Frankford Arsenal, Sandy Hook Proving Ground. One was also loaned to the Warner & Swasey Co. of Cleveland, Ohio, who had evinced an interest in the development of this type of sight. This company was requested to prepare and submit a design of panoramic sight which could be put into production in this country. This firm made up a design and a sample instrument.

When the panoramic sights were first put into production in this country, many manufacturing difficulties were encountered. Much trouble was experienced in getting the optical center lines and rotating center lines of the lenses and prisms to match. In each instrument of this type there are three prisms, one fixed and the others capable of rotation. The cross lines on the reticules were found to be too coarse for use when sighting on small objects. The lines often hid the object from view and, of course, made such an object hard to locate and hold. The azimuth worm had a tendency to shift its position, due to the shock of firing.

The cross lines on the new reticules were made thinner, allowing the glass reticules themselves to be reduced in thickness from one-tenth of an inch to one-thirty-second of an inch.

On July 29, 1905, the Frankford Arsenal authorities were instructed to prepare a complete set of tracings on linen, showing the latest design on sight. That arsenal was given an order for 140 sights shortly thereafter.

As a result of experience in the use of the Panoramic Sight, it was recommended that an entirely new design of sight be made up, having as one of its added features the objective head rotatable in elevation for angle of site usage and to facilitate picking up the aiming stake when the stake is on a different level than the sight. It was also recommended, January 22, 1912, that a device be added to the new design of sight allowing a deflection setting to be made without disturbing the original setting of the instrument. The required scale was to read 200 mils of deflection each side of the normal. A suitable open sight was to be added and in all cases, hand fitting was to be reduced to the minimum.

After approval of the design, a quantity of the new sights were made up and issued to the service. They were first called Model of 1913 sights, which designation was later changed to Model of 1915.

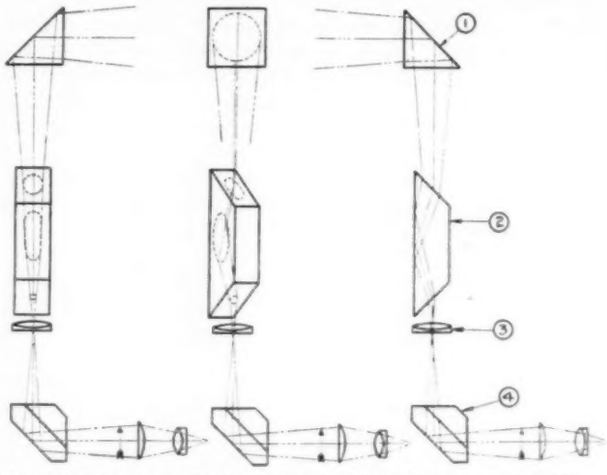
It was soon found that the 1915 sight was not a satisfactory design, either from a service standpoint or a manufacturing standpoint. The Field Artillery Board decided that the double worm mechanism for separate azimuth settings was not necessary. A great deal of trouble was had during the course of manufacture in maintaining the final accuracy required.

A new design was drawn up by the Frankford Arsenal and the 1917 model produced. This is now considered the service panoramic sight for field artillery. This 1917 model is similar to the 1904, but has the angle of site mechanism, a modified form of azimuth worm throwout, and a movable micrometer scale on the azimuth worm shaft.

A sight similar to the 1917 sight, but larger in all respects and with a higher magnifying power, has been developed to meet the needs of the railway artillery for a high power sight, and one rugged enough to withstand the shock of firing. This sight has interchangeable eyepieces, one of which gives 4 power, the other 10.

For the lighter infantry accompanying guns and pack howitzers, where weight and bulk are limiting factors, the 1920 model of panoramic sight has been developed. In this sight, the latest improvements put out by foreign manufacturers and those developed by the Ordnance Department, were incorporated. The "T" slot method of fastening the sight to its mount has been displaced in favor of the double cylindrical fastening, giving a positive seat, and insuring that the line of sight shall be in the same position each time the sight has been removed and replaced. The weight has been decreased, and the distance from the objective to the eyepiece has been lessened from nearly five inches to two and three-quarter inches. The eyepiece has been put on a 30 degree angle from the horizontal, making it unnecessary for the gunner to lie low to the ground when sighting. The main azimuth circle has been put on the outside of the instrument, doing away with the reading window device as used in previous models.

The accompanying plates show the main differences in construction of the several types of sights, but all being designed on the same optical principle, the one diagram suffices to show the path of the rays of light through the instruments of this type.



The prismatic system of the panoramic sight gives an erect image, as will be seen from the above diagram. The rays from the object are reflected by the prism 1 and are diverted from their course at an angle of 90 degrees, downward. The rotating prism 2 reflects and refracts these rays, inverts the image without reversing it and directs it into the object glass, 3. The resultant rays would be reversed and inverted if it were not for prism 4, which corrects the image seen, and diverts the rays again into the horizontal.

If the prism 1 is rotated through an angle of 90 degrees, while the other prisms remain stationary, a vertical object would appear as if horizontal in the telescope, the image being moved through 90 degrees. The rotating prism 2, when rotated around its axis (vertical) 180 degrees, produces a rotation in the image of twice the prism 1. Therefore, if the prism 1 is rotated 90 degrees, it is only necessary to rotate the erecting prism, 2, through 45 degrees to maintain the image in its true position. The prism 1 turns through 360 degrees, prism 2 through 180 degrees, and the observer always sees an erect image in the telescope.

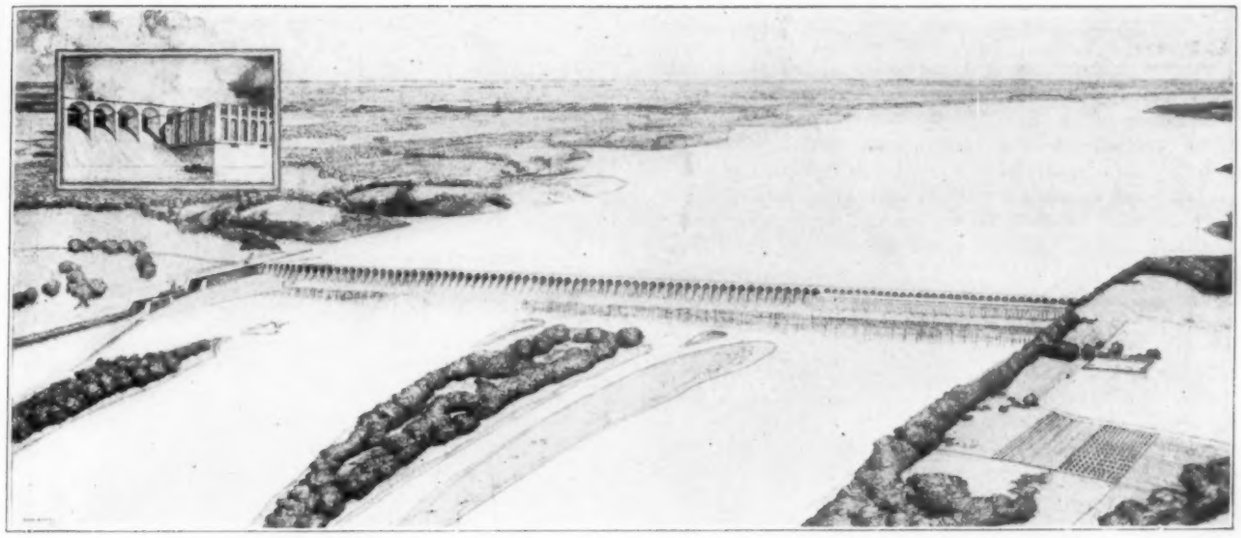


Fig. 1. Sketch showing Wilson Dam as it will appear when completed. Detail of power house and roadway in inset

The Wilson Dam at Muscle Shoals

By

STUART C. GODFREY

MUCH interest has been manifested of late in the activities that center around Muscle Shoals on the Tennessee River. The readers of this magazine are familiar with the two great nitrate plants that were erected in that vicinity during the war. It is the purpose of this article to deal with the power and navigation aspects of the development and to tell briefly the story of the huge but uncompleted structure that stretches across the river.

The Muscle Shoals and Their Early Development

Since the first white settlers came down the Tennessee, the Muscle Shoals have been recognized as the most formidable obstacle to the navigation of that river. Extending for about thirty-seven miles upstream from Florence, Alabama, the resistant strata of flint limestone which form the bed of the stream have prevented the river from cutting into the softer strata below, and caused it to spread out into a wide and shallow river, racing swiftly over a series of rocky steps, with low-water depths in spots of a few inches only. The total drop in this section is 134 feet; and velocities exceeding 10 miles per hour have been measured. The river is from one to two miles in width, and contains many islands. The banks are generally high and steep, the rocky cliffs towering in many places a hundred feet sheer above the river.

The Tennessee River itself is the largest branch of the Ohio. In fact, it is practically as large a river as the Ohio above their confluence, and the discharge, which varies from about 8,000 to 500,000 cubic feet per second, is sometimes greater than that of the Ohio. Although navigation on the Tennessee has not in the past been comparable to that on the Ohio, a good deal of progress has been made towards improving its navigable condition. From its mouth to the foot of Muscle Shoals a good channel has been developed. The project calls for a minimum depth of 6 feet at low water and of 5 feet at extreme low water. There are only one or two points at which these minimum depths have not been obtained. At the Muscle Shoals themselves, however, it is another story.

(Illustrations by courtesy of *The Military Engineer.*)

The first effort to surmount this barrier to navigation was undertaken by the State of Alabama, and a canal which paralleled a part of the Shoals was completed in 1834. This was unsatisfactory, however, and soon became obsolete. In 1871 a more ambitious project for the improvement of this section was authorized by Congress. This involved the construction of two lateral canals, with a total of 11 locks, 57 by 275 feet in size, and a navigable depth of approximately 5 feet. The remaining shoals were to be improved by the contraction of the low-water channel and by rock excavation. This project was completed in 1890, but as there are stretches of unimproved river above and below, comparatively little use has been made of it.

The combination of steep slope, high banks and great volume of water at this section of the river make it a favorable location for a large power dam or dams. This fact has long been recognized and for many years the dream of a big dam has been taking shape. Numerous examinations and surveys have been made under Congressional authorization, with a view to securing development of water power in connection with improvement of navigation, through the joint action of private agencies and the Government. A report favorable to development along these lines was finally made by the Corps of Engineers some six or eight years ago. The National Defense Act of 1916, however, authorized the establishment of a nitrate plant to meet the Government's requirements for military explosives. In view of the need of the Government for power to run this plant, the proposed contract with private interests for a joint project was abandoned.

The Wilson Dam

While the nitrate plants were being erected under the direction of the Ordnance Department, the Corps of Engineers was proceeding with the plans for the dam close by. The construction of the Wilson Dam (Dam No. 2 of the complete project) was directed in a letter from the President of February 23, 1918, under authority of the National Defense Act above referred to. The money allotted for its construction—a total of some $17,385,000—comprises the bulk

of the original twenty millions appropriated for a nitrate plant and appurtenances. The dam is to provide for the "generation of electrical power for the production of nitrates or other products needed for munitions of war, and useful in the manufacture of fertilizers and other products."

It will also ensure a minimum navigable depth of 9½ feet for a distance of 15 miles up-stream, to the proposed site of "Dam No. 3," another combined power and navigation dam some 50 feet high. Thus it is one of the strong arguments in favor of the Wilson Dam that the worst obstacle to navigation in the entire Tennessee River is eliminated by the dam, which drowns out completely the most troublesome shoals. "Dam No. 3" as planned would extend the slack water 30 miles further up-stream, well beyond the remaining shoals and beyond Decatur. From there to Chattanooga the complete navigation project is a comparatively simple one, involving only two or three inexpensive low-lift dams like the one already in process of erection at the Widow's Bar. The plans for "Dam No. 1," for navigation only, contemplate a small structure across the ship-channel two miles below the Wilson Dam.

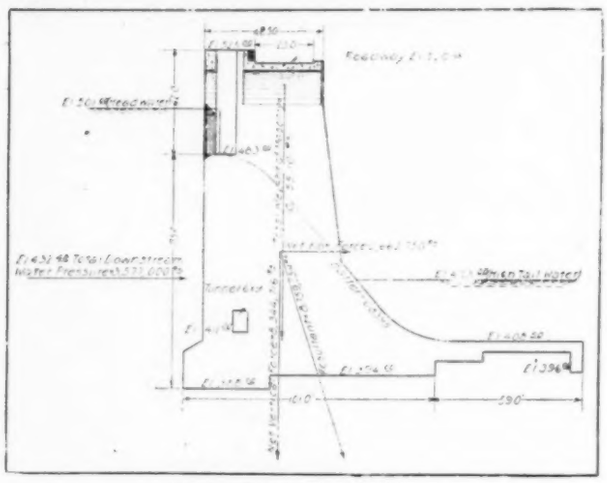


Fig. 2. Cross section of spillway

The Wilson Dam is of the overflow type, about 4500 feet long and nearly a hundred feet high. The entire structure, lock, spillway and powerhouse, is founded on solid rock, a hard, flinty limestone locally termed Lauderdale chert. This forms an excellent foundation. The excavation and tests made during construction have confirmed the favorable showing made by the very complete preliminary borings.

The locks are largely excavated from solid rock and are 60 feet wide by 350 feet long with a minimum depth over miter-sills of 7½ feet. There are two locks in tandem, each with a lift of about 46 feet. The lock gates are of the usual mitering type, and a double installation is provided for each lift to care for emergencies. A proposal of widening the locks to 80 feet is being considered.

The spillway section is 2,890 feet long. (See Fig. 2.) Eight-foot piers rise from the crest of the spillway to support an impressive concrete-arch highway bridge. In the openings between piers are installed vertical sliding steel gates, 18 feet high and 38 feet wide. These gates will pass without appreciable rise of upper pool level a flood 75 per cent greater than the highest ever known. The heel trench is 35 feet wide, and is carried down below the base of the dam so as to give a minimum breast wall of 5 feet without any seams. An inspection tunnel, 6 feet by 9 feet in section, runs straight through the spillway and power-house sections. Drill holes, on 23 foot centers, are sunk through the tunnel floor to a 35-foot depth, in order to relieve any upward pressure on the base of the dam.

The power-house section is about 1,200 feet long. (See Fig. 3.) The initial installation in the power house will consist of four vertical 30,000 H. P. turbines, operating at 100 revolutions per minute. These are direct connected to 25,000 K. V. A. 12,000 volt generators. Ultimately 14 additional units are contemplated. The head on the turbines varies from 93 to 68 feet.

Construction Methods

The construction of the dam presents no very unique problems. The most striking features of the construction plant are the 4-track construction bridge, and the 10-ton travelling cranes. The seven travelling cranes for the dam proper run on a special track, one rail of which is supported by the construction bridge-piers, the other by concrete piers so located as to be later submerged in the concrete of the dam. The 75-foot booms of these cranes span all four construction tracks and the base of the dam. In the power house section, three traveling full-circle cranes with 118 foot booms are installed. (See Figs. 4 and 5.)

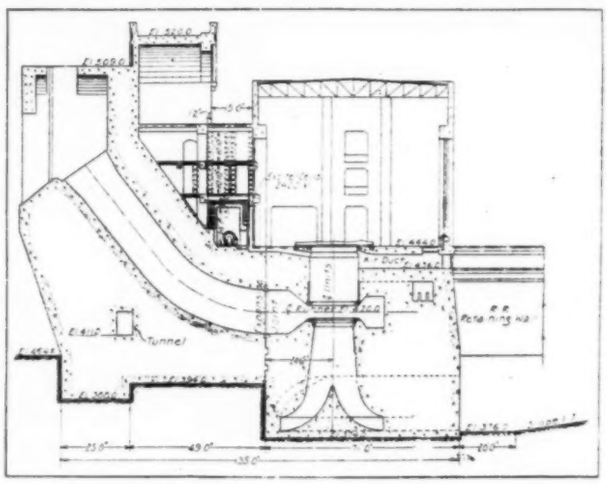


Fig. 3. Cross section of power house

Three mixing plants supply concrete, the largest of which on Jackson Island has two 4-yard mixers. The mixed concrete, of proportions approximately 1—2¼—5, is conveyed in 2 and 4 yard buckets on flat cars to the cranes.

A rock-crushing plant is located at the Jackson Island mixer, consisting of a 48-inch gyratory breaker and a battery of six 14-inch gyratory crushers. All excavated rock which can be used to advantage in the concrete is passed through this crusher and goes therefrom direct to the mixers. The bulk of the concrete aggregate, however, is sand and gravel.

Gravel and sand are obtained from a dredging plant located at Buck Island, 9 miles below the town of Florence. Two 15-inch hydraulic dredges pump the material to revolving screens mounted on a scow; from the screens the sand and gravel are spouted by gravity to barges moored alongside, which are towed to the dock at Florence by stern-wheel towboats. The material is unloaded into bins by two electrically operated gantry cranes and is then drawn off through bottom gates into 20-yard air-dump cars and hauled to the mixing plants at the dam.

The general plan of stream control at Wilson Dam is to enclose certain areas (seven in all) successively by cofferdams. These dams are of substantial rock-filled cribs, sheeted with lumber, and sealed with clay and earth. In the spillway the concrete is first brought to elevation 411, about 7 feet above the river bed. From this elevation certain sections of the dam, including the arch bridge, are completed at once in successive lifts. In other sections, cor-

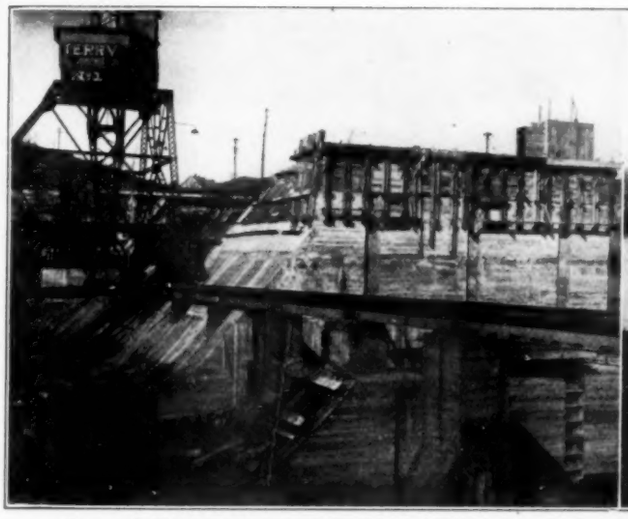


Fig. 4. Spillway near north, or lock, side. Concrete carried to Elevation 446, February 4, 1921

Fig. 5. General view from north, or lock, side. Cofferdam No. 1 carried to El. 411, or higher, Jan. 1, 1921. Note construction and travelling cranes.

responding to the river channel, the piers only are raised above elevation 411, leaving openings through which the river discharges. When the remainder of the structure is finished, the 42 openings will be raised by successive 6-foot lifts to the crest of the spillway.

Progress of the Work

The first steps toward the actual construction of the Wilson Dam were taken in 1918. During the spring of that year a small force was gradually assembled, and the preliminary work of constructing a camp and assembling plant was commenced. In the fall of the year, however, all work was suspended on account of the pressure of other war activities. During 1919 more substantial progress was made. A commodious construction camp was erected, housing a small city of 3,000 people (see Fig. 6); the first cofferdam was completed and pumped out September 1, 1919; the construction bridge was 50 per cent completed; the railroad lines, yards, shops and warehouses were largely finished; and the greater part of the plant was assembled.

During the spring of 1920 the work of excavating in the first two coffers and of constructing the power house cofferdam (No. 6) was pushed vigorously. The construction bridge was put into service, and the ten big travelling tower-derricks erected. On May 7 the first concrete section of the apron of the Dam was poured inside the Jackson Island cofferdam. The procurement of supplies in adequate quantity became a serious problem at this time. Markets were depleted, traffic was jammed, and deliveries were painfully slow. The problem of securing cement, for instance, was solved only by the purchase of seventy-five rebuilt box cars, which were devoted exclusively to the cement service between the mills and the dam and which transported over 100,000 barrels of cement.

On September 29 the preparatory period fairly ended. The average daily yardage of concrete jumped from about 100 to 1300 cu. yards. (The *best* day's run was 2,188 yards.) The winter of 1920-21 was an exceptionally favorable one, and scarcely a day was lost, by flood or otherwise, in the vigorous prosecution of the work. (See Fig. 7.)

The power house cofferdam was unwatered in August, 1920, and rapid progress was thereafter made on the great amount of rock excavation necessary for the draft tubes and tail-race, comprising over 300,000 cubic yards. (See Fig. 8.) The first concrete in the power house section was poured on February 1, 1921.

In the spring of 1921, with the failure of the item in the Sundry Civil Bill asking for an additional ten millions, it became necessary to stop construction. In March, when construction was at its height, a force of some 4,000 men produced the largest month's output of concrete—about 47,000 cubic yards. From that time the force was gradually but steadily reduced, until by June 30, a handful of a few hundred only was left, completing the cleaning up and caring for the property and plant. This force, though small, has been held intact and comprises a nucleus including three

Fig. 6. Portion of camp. Permanent houses in foreground; married negroes' quarters in background

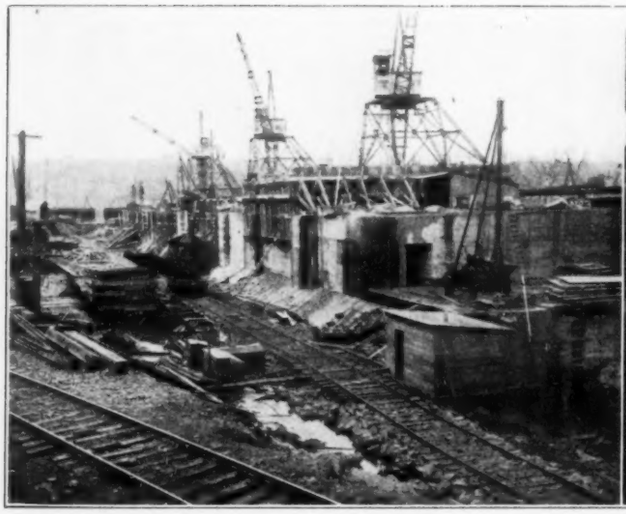


Fig. 7. Masonry in one of Jackson Island cofferdams from upstream side. Note heel trench and inspection tunnel

Fig. 8. Excavating for power house foundation

Officers of Engineers that could be expanded without great delay into an efficient organization.

Available Power

Statements as to the amount of power available at Muscle Shoals have not always been accurate. However, gauge readings at Florence for a period of over fifty years are available, and from them and various discharge measurements a power curve has been plotted showing reliably the percentage of time that any particular amount of power will be available.

The primary power at the Wilson Dam has often been spoken of as 100,00 H. P. This is not the absolute minimum, but represents what can be expected for over 97 per cent of the time. A conservative figure for primary power has been placed at 87,300 H. P., which amount has been maintained for 99½ per cent of the entire fifty-year period. Similarly the amounts of secondary power that can be expected during a part of the year only are as follows:

141,000 H. P. for 83⅓ per cent—10 months per year
205,000 H. P. for 66⅔ per cent— 8 months per year
306,500 H. P. for 50 per cent— 6 months per year
600,000 H. P. for 21 per cent— 2½ months per year

The corresponding figures for the proposed Dam No. 3 are about 40 per cent of the above. The Government steam plants at Nitrate Plant No. 2 and Gorgas have a combined capacity of approximately 120,000 H. P. If all this steam power were used to supplement the water power made available by the Wilson Dam, the combined result would be a dependable primary of over 200,000 H. P.

That there is some unfilled demand and a constantly growing need for power in this region is evidenced by two recent developments—the construction now under way by the Alabama Power Company of a new dam on the Coosa River which will develop eventually over 100,000 H. P., and the lease of the Government steam plant at Nitrate Plant No. 2 to the Alabama Power Company whereby the needs of that concern and neighboring power companies may be supplemented, especially during periods of low water.

Present Status

The Wilson Dam as it stands is fully one-third finished. The more difficult work is done—the assembling of plant, the greater part of the cofferdam work and rock excavation, the pouring of two-thirds of the foundations. The equipment is well stored, but deterioration of plant, of cofferdams, etc., is merely a matter of time, and serious losses are bound to occur if any long delay intervenes before the resumption of work. The annual depreciation of all plant is estimated at $400,000. The first four turbines and generators are approaching completion in the I. P. Morris and Westinghouse shops, respectively, and much of this machinery has been shipped. A total of about seventeen million dollars has been spent or committed, to date. The Engineer Department estimates that about twenty-eight million dollars additional will be necessary to ensure its completion in accordance with present plans. (Only three-fourths of this is needed to install the first four power-units complete.) The dam can be completed, it is estimated, within three years; an appropriation of seven millions would enable the work to be carried on at maximum efficiency for one year.

The great publicity which has been given to this project recently has been caused largely by Mr. Ford's offer to purchase the plant for the stated purpose of manufacture of nitrates. This offer was the result of the letter sent out by the Chief of Engineers in April, 1921, in compliance with instructions of the Secretary of War to ascertain if an offer for Muscle Shoals could be obtained from private interests which would indicate that it was a reasonable business proposition.

The consideration of Mr. Ford's offer and of other offers that have followed it involve many complicated factors, such as financing of the completion of the dam, the practicability of operating the plants on secondary power from the dam, the relationship of the Government steam plant at Gorgas to the development at Muscle Shoals, and the like. It is significant, however, that all these offers are alike in contemplating the completion of Wilson Dam, if not of other dams. It will constitute a vast reservoir of power in an expanding territory which has need of that power; it promises to supply the most difficult link in a water transportation chain which taps this same section rich in natural resources; joined with two plants of such great nitrate producing capacity it constitutes an asset of tremendous significance. Add to this the fact that the Wilson Dam is so far advanced towards completion and it seems a great waste and pity to discard or neglect it at this stage. Those who go to Muscle Shoals and see the extent of the work that has been done and its future promises are almost invariably converted into enthusiastic friends of the project and desire earnestly to see some feasible plan worked out that will ensure its early completion.

The Aberdeen Proving Ground

By

H. W. SCHULL
Member A. O. A.

THE article in ARMY ORDNANCE for March-April, 1921, entitled "The Aberdeen Proving Ground" gave a general outline of the Aberdeen Proving Ground, its growth during the war and its history. In the present article, within the limits of space allotted, an effort will be made to describe briefly some of the more important additions, improvements and changes that have been made in the work at the Proving Ground, as the result of the transition from the war-time to the peace-time function of the establishment.

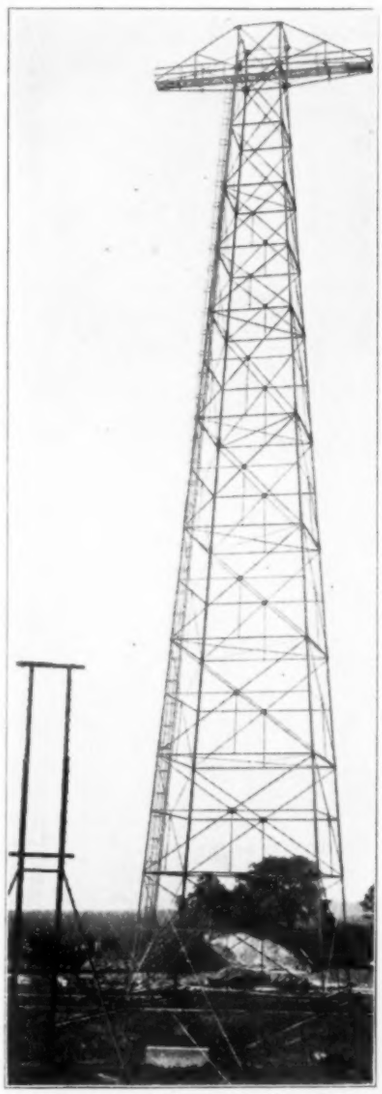
The Proving Ground site was selected and the plant was developed along its present lines to meet the conditions imposed by the World War. These conditions required principally a land area sufficiently remote and extensive to permit the various activities connected with the proof of cannon, ammunition, and so forth, to proceed simultaneously and uninterruptedly without undue danger or disturbance to the surrounding communities.

The major part of the work of the Proving Ground, during the war period and for about a year thereafter, was that incident to the proof and acceptance tests of cannon and ammunition procured under the Ordnance Manufacturing Program, either by contract or from the government arsenals.

At the same time, a considerable amount of experimental and development work was carried on at the Proving Ground, but this work represented necessarily but a small percentage of the total work performed.

The operation of the Proving Ground during the war period was connected directly with, and might be considered part of, the Manufacturing Program, inasmuch as its work was mainly in the nature of final inspection and acceptance of cannon and ammunition subjected to proof firing.

Since the close of the war, however, it has been necessary to undertake a gradual change in the function and organization of the Proving Ground to adapt it to its peace-time duties. During the war, the paramount question was the accomplishment of a maximum volume of proof and acceptance work. In time of peace, this question becomes relatively less important, and the primary function of the Proving Ground becomes the performance of experimental work incident to the test and development of new types and designs, and improvements in existing designs of cannon, ammunition and other ordnance matériel.



Steel Tower for Taking Muzzle Velocities at High Angles of Elevation

At the close of the war, the proof work being done at the Proving Ground may be measured from the fact that from five thousand to seven thousand rounds a day were being fired with cannon of 75 mm. caliber and above, mostly in proof of cannon and ammunition. A large part of this firing was with high explosive shell of various calibers, trench mortar ammunition and other ammunition requiring special facilities; and, to enable this work to go on simultaneously without interrupting other activities, it was necessary to construct a number of widely separated firing ranges.

There were five main firing positions developed, known as the Main Front, not far from Headquarters Building, where cannon of various calibers up to 9.2" were proved; the Mulberry Point Range, about three miles from Headquarters Building, where railway and seacoast cannon were fired; Detonating Ranges Nos. 1 and 2 at Michaelsville, six miles from Headquarters Building, where high explosive ammunition was tested; the Trench Warfare Range, about one mile from Headquarters Building, where trench warfare ammunition and cannon were tested; and Detonating Range No. 3, about one mile from Headquarters Building, supplementing Detonating Ranges Nos. 1 and 2.

The arrangement referred to in the preceding paragraph was necessary and entirely satisafctory under war conditions, when a great volume of proof and acceptance firing of ammunition and cannon had to go on simultaneously. Under peace conditions, however, the necessity for greater economy and convenience in the conduct of work, the increase in the diversity of proof work due to the development of new types, and the introduction of new and improved methods have required the concentration of the activities at the Proving Ground into the smallest practicable areas, and the development of better and more highly specialized facilties.

Since the close of the war, while the volume of the work at the Proving Ground, as represented by the number of rounds of ammunition fired in a day, has fallen off, the actual scope and character of the work performed have greatly increased and expanded due to the concentration at the Proving Ground of experimental and development work

which, during and immediately following the period of the war, either could not be carried out at all, or was being done at other establishments. This concentration of work has necessitated the addition of many new and the improvement of existing facilities during the past two years.

One of the most important of the new facilities that have been provided is the Small Arms and Machine Gun Firing Range for testing small arms and ammunition therefor, which was described in detail by Major L. O. Wright in the March-April, 1921, number of ARMY ORDNANCE. This range was completed in June of 1921 and has been in successful operation for about ten months. It has a total length of about 7,200 yards, and terminates in a pool of water 1,000 yards long formed by the waters of Romney Creek.

The range is almost level throughout its entire length and is excellently adapted to the purposes of testing the ballistics of small arms, machine guns and ammunition. Armored range towers for observing the impacts of bullets on the water area have been installed. A narrow gauge railway runs the entire length of the range and two gasoline locomotives with cars are provided for the transportation of personnel and material.

Another important addition to the proof work at this establishment during the past two years is represented by the development of the methods and facilities for conducting standardized tests of automotive matériel, including military tractors, self-propelled mounts and tanks. Practically none of this work was done here during the war or the year following the war, and it has been necessary to train a personnel, provide facilities and decide upon standard methods of testing these vehicles.

The tests to which these automotive vehicles are subjected at the Proving Ground have been carefully worked out and are designed in each case to determine and demonstrate whether or not the vehicle is properly adapted to the purpose for which intended. To accomplish this, vehicles are subjected to extensive road tests, representing all conditions of terrain likely to be encountered in actual service.

A careful record or log is kept, showing the performance of a vehicle during the road tests, including the number of miles run, gasoline consumption, oil consumption, and any unusual occurrences. In the road tests of tractors and self-propelled mounts, the draw-bar pull is carefully measured and recorded on a recording draw-bar dynamometer. The test of an automotive vehicle includes also a thorough examination and inspection of the mechanical and engineering features of its design. To accomplish this, the vehicle is more or less completely disassembled in the machine shop during the tests.

These tests may also include a block test of the power plant of the vehicle to determine whether or not the engine is developing the prescribed power, in accordance with the specifications under which it is designed. To perform this feature of the test, there is installed in the machine shop at this establishment a Sprague electric dynamometer of 400 horsepower capacity.

During the past year, to assist in carrying out the program of bomb development, there has been added to the equipment of the Proving Ground a dirigible balloon or airship of the C-2 type to replace the captive balloon theretofore used. The use of this airship greatly facilitates proof work in this section, in that maneuvering over targets is much more readily accomplished and the bomb-carrying capacity is increased.

A new steel hangar, 220 feet long by 70 feet wide by 75 feet high, for housing this airship, together with a landing field and other suitable facilities, including three smaller steel hangars for a machine shop, a hydrogen-generating plant and a storage plant have been constructed. For the operation of the airship and to assist in carrying out the bombing tests, the 18th Airship Company, consisting of 4 officers and 130 enlisted men, is stationed at this establishment.

A subject of great importance which is incident to the bomb development is that of the trajectory of bombs of various types when dropped from aircraft. For the further and more effective study of this subject, new and improved facilities have been designed during the past year and are now being installed. These facilities consist of a camera obscura mounted at each end of the base line by means of which the image of an aircraft as it passes through the field of the lens of the camera is thrown upon a screen and may be accurately plotted.

Each camera obscura is arranged to have motion both in elevation and azimuth so that, with a fixed base line, the position of the aircraft in the air at any instant while it is in the field of the lens may be plotted and determined. The base end stations are equipped with suitable time recording devices and these are synchronized by means of a master clock.

The operation of the system is, briefly, to plot upon the screen in each camera obscura station at the ends of the base line the position of the image of the aircraft at the instant a bomb begins to fall and thus determine accurately its position in the air at that time. The time of flight of the bomb until it strikes the ground is determined by direct observation. The distance on the ground to the point of impact of the bomb is measured. There are thus secured all the data necessary to calculate the trajectory of the bomb.

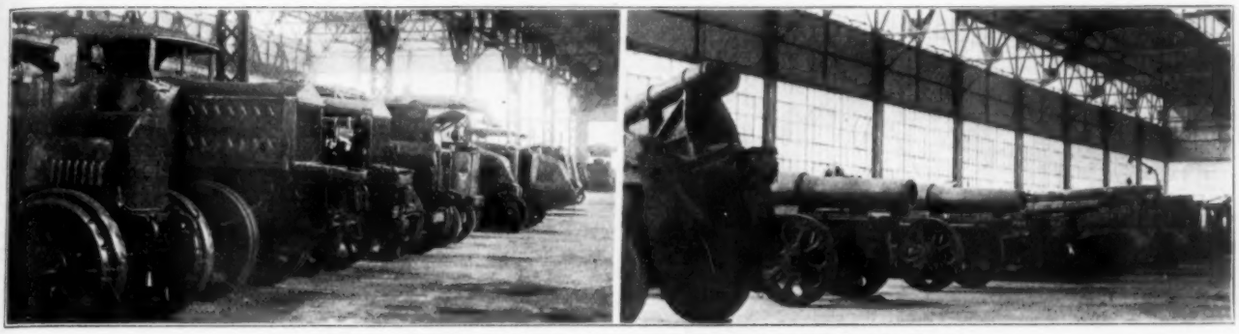
Extensive improvements in the Aviation Field for airplanes have been undertaken during the past few months. These improvements cover grading the field so as to afford four intersecting runways, each about 300 feet wide by 1200 feet long, with a gradient not exceeding 4 per cent throughout their length. This work, which requires the removal and redistribution of about 50,000 cubic yards of earth and the resodding of quite a large area, is now well underway and should be completed in the next three months.

Improved means for the observation of fire over the land ranges have been provided during the past year. These have included an accurate survey of the land ranges, the construction of substantial concrete bomb proofs for the shelter and protection of observers at 1100 yard, 2500 yard, 3500 yard, 4500 yard, 7500 yard and 9500 yard ranges from the firing protections at the Main Front. From these bomb-proofs the action of fuses and projectiles on impact with the ground may be readily observed and inspected.

For the observation of fire over water ranges, towers are provided along the Eastern Shore, and for the fire of the highest power guns, such as the 16-inch gun, it is necessary to provide for ranges as great as 60,000 yards, and to have a satisfactory means of communication over this range. Provision has been made for the installation, in the most distant range towers, of new wireless telephone equipment of a type sufficiently powerful to communicate with the firing position.

Tests, proof work and investigations of a nature vitally important to the Army, in addition to those hereinbefore mentioned, are at all times in progress at this establishment, and it is regretted that space does not permit more than the briefest mention of a few of these in the remaining paragraphs of this article.

Early in 1921, the type of the new 75 mm. pack howitzer arrived at the Proving Ground from the Rock Island Arsenal. This piece was followed by the guns and carriages representing the new divisional artillery matériel, including the 75 mm. gun and 105 mm. howitzer of various models,



Captured Enemy Tractors and Cannon, Ordnance Museum, Aberdeen Proving Ground

both of the wheeled and self-propelled types. The tests of all this matériel are now well under way.

There also arrived here for proof during the past year the new 16-inch barbette carriage, mounting a 16-inch 50-caliber gun for the seacoast fortifications, the largest of its type in the world; also, the 16-inch howitzer, mounted on a carriage of a similar design to that of the 16-inch gun. The proof of the gun is practically completed and that of the howitzer is under way.

During the past year, the work of making a complete firing test to determine the condition of all the reserve ammunition accumulated during the war and on hand in the storage depots was undertaken at this establishment. This test, which involves the firing of approximately 50,000 rounds of various calibers from 37 mm. to 12 inches, and also tests of hand grenades and trench warfare ammunition, was begun in September, 1921. By April 16, 1922, about 36,000 rounds, representing 76 per cent of the program, had been tested.

Important investigations, having for their object the development of the solenoid chronograph for use in measuring the muzzle velocity of projectiles and other time intervals, have been in progress for some time at the Aberdeen Proving Ground. This instrument, which has been developed to the point where its use is quite practicable for this purpose, is extremely accurate and is a valuable addition to the Proving Ground equipment where a greater degree of accuracy than that possible with the Boulenge chronograph or the Aberdeen chronograph is necessary.

The solenoid chronograph is now finding its use in an important experiment to determine the interior and exterior ballistic data of the 240 mm. howitzer mounted on a special free recoil carriage. This experiment involves the measurement of the velocity of the projectile at 12 points in the bore of the cannon and at from 4 to 6 points in front of the muzzle of the cannon. Also, the instrument is being employed to measure the velocity of fire recoil of cannon.

Reclaiming 2½ Ton Tractors, Model of 1918

By

LEVIN H. CAMPBELL, Jr.

Member A. O. A.

IN the latter part of the late war the 2½-ton Artillery Tractor, Model of 1918, was designed with a view to motorizing 75-mm. artillery organizations, reel carts and the caisson companies of the divisional ammunition train. Approximately 116 of these tractors are on hand. Briefly the characteristics of the tractor are:

Weight 7,800 lbs.
Length overall 120 inches.
Width overall 58 inches.
Draw-bar pull 4,000 lbs.
Brake horse power of engine at 2600 R. P. M—70.
Road speed at 1500 R. P. M. of motor: low 3 miles per hour; intermediate 7 miles per hour; high 9 miles per hour.
A speed of 12 miles per hour is obtainable for reasonable distances at 2,000 R. P. M.
The power plant is the Cadillac 8 cylinder passenger car motor equipped with a magneto.

It is known to those in the service who have used this tractor that it has not proven satisfactory, due to the short life of the motor which must run at very high engine speeds to develop the power required. From an examination of Figure 1, it will be seen that the gas tank is at the extreme front of the vehicle and the air which is drawn through the radiator by the fan enters at right angles to the direction of motion of the vehicle, which results in very poor cooling of the engine water. The oil in the crank case has reached temperatures as high as 210° F. Crank case oil should properly never exceed 160° F. in temperature. The result of the lack of sufficient air to cool the engine water and the high crank case temperatures has been that the bearings of the motor are very quickly "shot" and the cylinders soon worn out of round. The delays on the road incident to overheating of the engine were very frequent.

For some years past it has been suggested by various people, among whom may be mentioned Mr. P. E. Holt, Director of Engineering of the Holt Manufacturing Company, and Major Maxwell Murray, of the Field Artillery, that another motor be installed in this tractor with a view to overcoming the difficulties enumerated above.

The writer suggested to the Commanding Officer of the Aberdeen Proving Ground and the Technical Staff of the Ordnance Department that a standard Class "B" Liberty truck motor be installed in this tractor in the place of the Cadillac motor. Their approval was readily given and work at once initiated in the Tractor Department of the Proving Ground. Referring to Figures Nos. 2 and 3, an idea may be gathered of the changes made necessary in the installation of the truck motor. These changes are here briefly outlined. All armor was removed from the tractor. The main frame was lengthened by the addition of two short pieces of angles to support the radiator. The clutch housing was secured to the fly-wheel bell housing of the truck motor by use of an adapter plate. Connection with the fly-wheel of the truck motor from the clutch was

Fig. 1. Original 2½-Ton Artillery Tractor, Model of 1918

Fig. 2. Reclaimed 2½-Ton Tractor, Model of 1918

made by bolting the Cadillac flywheel, with starting teeth machined off, to truck motor flywheel. The truck lock, which is the cross member tying the two trucks together, interfered with the oil sump of the new motor. Therefore, a new truck lock beam was made to clear the sump. A new gas tank of forty (40) gallons capacity was installed on the shelf in rear of the driver's seat. The motor was supported in the front end by a standard 5-ton front motor support and in the rear by two angle brackets. A Standard Liberty truck radiator was used and the regular water outlet was closed off and a new outlet provided in order to secure a better lead for the radiator hose connection. The standard Liberty motor hood was used.

It is desired to mention the fact that the failure of the truck spring dowels had been of frequent occurrence in the Model 1918 tractor. This trouble has been very definitely overcome here by using a ⅝-inch dowel bolt instead of the ⅜-inch supplied. Another trouble which should be corrected in this tractor is the fact that the splined coupling between the change-speed set and the transmission is too light and after about 600 miles of test failed, due to the splines being sheared off. This fault may be readily corrected by using a larger connection in this place.

The tractor as modified was put on road test and has run a distance of 800 miles over typical country roads towing either the 75-mm. Gun and limber, Model 1921E, or the ¾-ton trailer (Dodge parts with Chase Track) loaded variously to its rated capacity of 1,500 lbs. or with 50 per cent overload. During this test a new track was put on after 600 miles running and a new spline coupling, referred to above, was installed. Aside from this trouble there has been no difficulty experienced in the operation of the tractor which has run at an average speed of 7 to 8 miles per hour. This performance, accomplished in 14 days, is an entirely new experience in tractor testing for the Proving Ground. The gas consumption has proven to be about ½-gallon per mile, and the oil consumption about that normally encountered with this motor in use in the Liberty truck. The weight of the tractor has been reduced from 7,800 lbs. to approximately 7,200 lbs. and the appearance has been very much improved.

It is the belief of the writer that by using a motor which is over-powered for a tractor a great increase in the life of the motor results, and the test of the Modified 2½-ton Tractor seems to bear out this statement. The case may aptly be compared to a horse: underworked, his life is long; overworked, it is very short.

It is understood that there are sufficient Class "B" truck motors on hand which may be obtained without the expenditure of funds, to equip all of the 2½-ton tractors on hand. Too great emphasis cannot be laid on the fact that the parts of Class "B" motor are largely interchangeable with those of the 5-ton tractor motor. The supply of parts in the field would thus be greatly simplified.

A complete set of drawings of the changes involved has been completed and should it be so desired, the parts can be manufactured at an arsenal and shipped to the field for installation.

Mr. E. W. Barnhart, in charge of tractor development work at Aberdeen Proving Ground, is given full recognition of his suggestions and services in the work of installing the new motor in the tractor.

Fig. 3. Reclaimed 2½ Ton Tractor, Aberdeen Model of 1918

Special Engines for Motor Carriages

By

GEORGE SCHUSTER

THE design of the motor carriage for the 155 mm. gun and 8-inch howitzer and the carriage for the 155 mm. howitzer and 4.7-inch gun required engines having low overall height in order to give a low trunnion height for the gun and a low center of gravity for the carriage. There were two methods available for securing the necessary low engine height, one of which was to use a V-type motor and

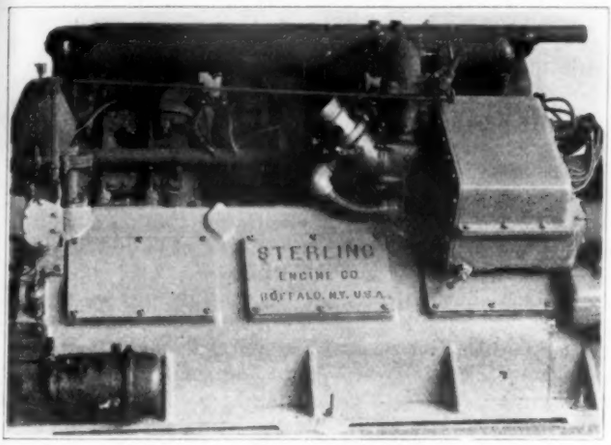


Fig. 1. Inlet Side of 6-Cylinder Engine

the other a half V-type. A study of existing types showed that there was not available in the market a V-type having the proper characteristics. It was found possible, however, to adapt an existing type of engine to the half V-type by modifying certain parts. As a result, there have been produced engines in four and six cylinder sizes having the necessary modification to make them suitable for the special requirements of motor carriages, and yet use a maximum number of parts always in production, parts that have been tested out over an extended period in commercial practice. In addition, these engines, due to the half-V construction, are very accessible. This is a desirable feature for motor carriage work on account of the location of the engine in chassis of the machine.

The engines selected for modification for this special purpose are in production by the Sterling Engine Company of Buffalo, N. Y. This company has had a wide experience in building commercial engines of the heavy duty type. The overhead four valve type of engine developed by this company was designed by them as a result of their experience in commercial work and in building special engines for the government during the war. The dual valve type was selected, as it had the proper power characteristics for use in the motor carriages. The general appearance of the half-V type engine is shown by the accompanying illustrations.

The general characteristics of the two engines are as follows:

Designation	*GRVT-4*	*GRVT-6*
Bore	5¾-inch	5¾-inch
Stroke	6¾-inch	6¾-inch
Cylinders	4	6
Weight	1740 lbs.	2250 lbs.
Horsepower	170	240
Maximum Speed	1800	1800
Governed Speed	1400	1400
No. of valves per cylinder	4	4
Location of valves	Overhead	Overhead
Ignition	2 Magnetos	2 Magnetos
Carburetor	2½-in. Stromberg	2½-in. Stromberg
Starter and Generator	Northeast	Northeast
Cooling pump	Centrifugal	Centrifugal
Fans	1-24 inch	2-22 inch
Oiling System	Pressure	Pressure

The cylinders are mounted on the lower base and are held in place by studs and nuts. A heavy vellum gasket is used under the cylinders. Large openings are provided on the side of each cylinder and the cover plate can be removed to give the water jacket a thorough cleaning should any sediment collect in the water space.

The general construction of the cylinder heads is shown by the photograph. Each head contains four valves, two inlet and two exhaust. The mechanism for operating the valves consists of four forked rockers mounted in pairs on two shafts. The shafts are mounted in a bearing which is held in place by six bolts. The entire assembly consisting of rockers, rock shaft and bearing can be removed as a unit when it is necessary to do so. The rocker shaft is oiled by a pressure feed pipe from the main oil header.

Valve tappet clearance is adjusted by means of a screw in the end of each fork of the rocker. The adjusting screw is clamped in place by a bolt which clamps the end of the tappet on the screw.

The push rod end of the rocker has passing through it a

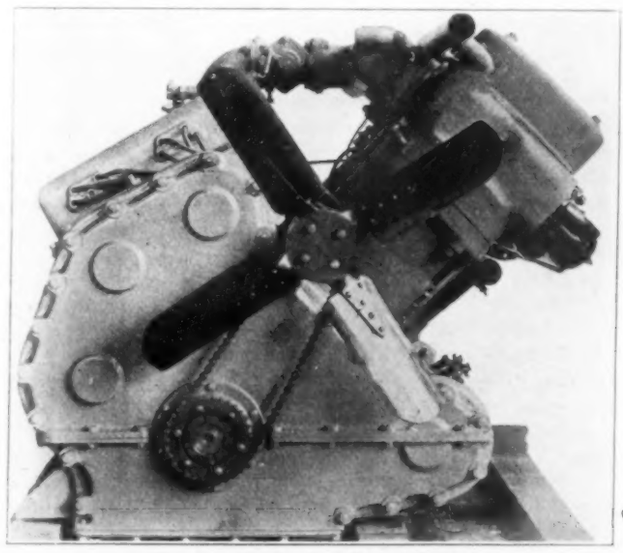


Figure 2. Timing Gear End of Engine

hardened steel pin which is spherical on the under side to engage the cupped end of the push rod.

The oil which lubricates the rockers, passes out between the rubbing surfaces and back to the crankcase through the tubes surrounding the push rods.

The valve spring seats are cupped washers held in place by a split collar which fits into a groove in the valve stem. To remove a valve spring it is only necessary to compress the spring enough to allow the spring seat to clear the collar, after which the split collar can be removed, thus freeing the spring seat and spring.

The cylinder, cylinder head with all parts, are parts from

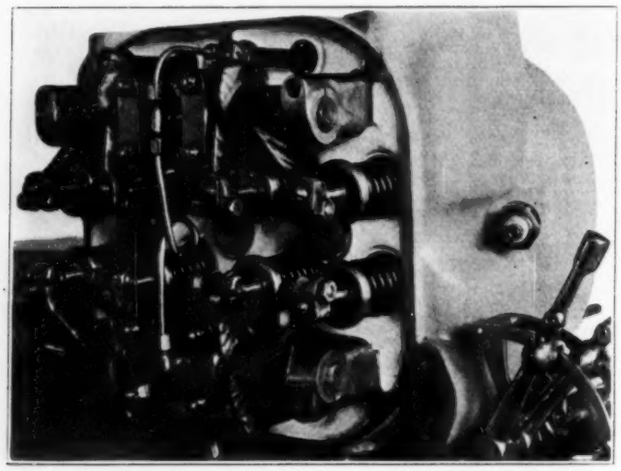


Figure 3. View of Cylinder Head Showing Valve Operating Machine

the regular line of engines built by the Sterling Engine Company.

The crankcase is of special design to permit of mounting the cylinders at 45 degrees. The interior construction of crankcase, which is of cast iron, conforms to the regular practice of the manufacturers.

A special sump of aluminum is provided. In order to reduce the overall height of the engine, the regular sump construction had to be modified and replaced by a shallow pan, provided with a shallow oil sump at each end. Each sump is covered by a fine mesh copper netting to screen the oil, before the oil passes to the pumps.

The pistons are of aluminum, of the "Ricordo Slipper" type. Four narrow piston rings 0.155 inch wide are used. The wrist pin or upper connecting rod bearings are directly in the aluminum bosses of the piston. The fitting is very close and the pins are a hard push fit into the bearings. The connection rod upper end is split and clamped onto the piston pin. Iron pistons are furnished for the commercial type of engine, but in order to operate at higher speeds, the aluminum pistons were used.

Ignition is by two K. W. Type "TK" magnetos. There are two spark plugs in each cylinder head, each magneto providing current for one set of plugs. The cylinder heads are normally provided with three spark plugs but with the inclined cylinders construction only two are accessible. The magnetos are provided with impulse starter couplings. The standard couplings have been modified to give a maximum spark advance of three-fourths inch.

Lubrication of the engine is entirely automatic except for occasional lubrication of the magnetos. Oil is forced under pressure to the main bearings, connecting rods, timing gears and valve workers. The oil pump is of the triplex type consisting of two scavenging pumps and one pressure pump combined in one unit. The pump is located in the housing at the front end of the crankcase and is gear driven from one of the camshaft gears. The scavenging pumps are larger than the pressure pumps so that one pump can remove all the oil from either end of the crankcase when the engine is operating on steep grades. All oil passages are cast in the pump and connect with passages to the crankcase so that the pump is independent of separate pipe connections.

On account of the shallow pan used, an outside oil tank is used into which the scavenging pumps discharge and from which the pressure pump is supplied. The supply tank is located above the pressure pump to insure priming.

The magneto and water pump bearings are lubricated by oil discharged into pockets over the bearings. A stream of oil from the pressure line is directed onto the timing gears.

The valve rocker arms receive oil from the hollow shafts upon which they are mounted by tubing connected to the crank case oil manifold. The oil which escapes from the rockers lubricates valve stems and tappet screws. This oil finally flows from the head through the push rod tube, oiling the push rod and roller before returning to the crankcase.

The oil pressure line has a relief valve by which excess oil is discharged back into the crankcase. The normal oil pressure with wide open throttle is 25 to 40 pounds. This reduces as the load reduces and when running idle at high speeds will be about one-third of the full load pressure. This pressure regulation is obtained by reducing the spring load on the relief valve piston, the cylinder of which is connected to the inlet manifold with tubing. The vacuum or lower pressure produced by closing the throttle moves the piston away from the valve, allowing it to by-pass some oil from the oil manifold into the crankcase. The reduction of oil pressure during light load operation reduces the amount thrown onto cylinder walls and less oil is available to be driven by the pistons. Less oil reaches the explosion chambers, resulting in cleaner exhaust and spark plugs.

The crankshaft is counterbalanced and is supported in bearings located at each end of the engine and between each pair of cylinders. The crankshaft bearings are lubricated by force feed, each bearing receiving oil from the main pressure pipe. Oil is fed from each main bearing to the two cranks on either side of each main bearing.

The flywheel is of cast steel instead of cast iron, the commercial construction. This change was made on account of the higher speed at which the engines will oper-

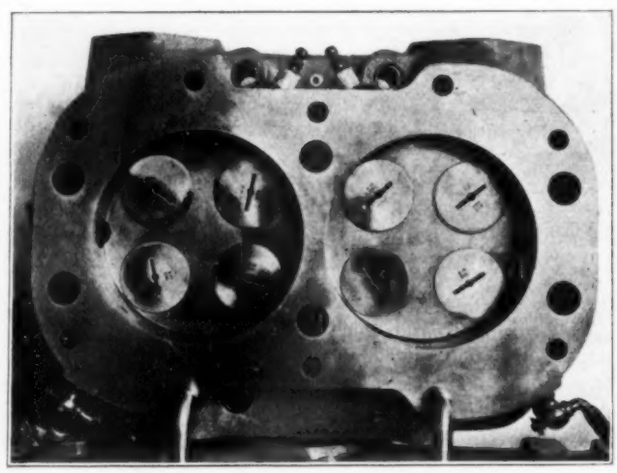


Figure 4. Inside View of Cylinder Head

ate in the motor carriages. The flywheel has cut in it the teeth for the female member of the coupling between engine and transmission. The starter ring gear is bolted to the flywheel.

The carburetor is a modification of the Standard NS-7 type Stromberg Carburetor. These carburetors are of the plain tube type having no automatic air valves or other

moving parts except the throttle and float mechanism. All the gasoline for normal running is taken through one regulating opening and the proper mixture preparation is maintained by the principle of taking air into the jet passage along with the fuel, so that the combustion of air and gasoline discharge from the jet. At very low idling speeds the gasoline from the main jet is carried up in a passage at the side of the carburetor, and discharged from an idling slot at the lower edge of the throttle.

The carburetor has an auxiliary gas needle control lever, which is raised until the engine is warmed up. A choke is also provided for momentary use when starting.

Both engines are equipped with gasoline gear pumps driven from the inlet camshaft. The gasoline pump is located on the crankcase at the flywheel end. The pump is in the fuel line between the supply tank and the carburetor, and delivers gasoline to the carburetor under low pressure. To prevent excessive pressure on the carburetors a by-pass is provided which returns the excess gasoline to the suction line of the pump. As the gasoline tank is above the pump, the pump is always primed so long as there is fuel in the tank.

The governor throttle located between the carburetor and the intake manifold is controlled by a flyball type governor. The governor is adjusted for a maximum speed of 1400 r. p. m. The governor is located at the flywheel end of the engine on the intake side and is driven by the inlet camshaft.

A hand priming pump, drawing fuel from the carburetor or fuel line, discharges into the inlet manifold near the valves of each cylinder. This pump is used for starting only.

The cooling water is circulated by means of a centrifugal pump located on the exhaust side of the engine. The pump shaft also drives the generator. The six cylinder engines have two 22-inch fans, while the 4-cylinder engines have one 24-inch fan. The fans are of the "Hy-Duty" type, made by the Automotive Parts Company. Both sizes are four bladed and have a coil spring drive, that is, a coiled spring is used to transmit the driving torque from the sprocket to the spider. This form of drive is necessary with the chain drive. The driving chains are "Diamond" roller type.

Some attempt at waterproofing has been made with these engines for operating submerged. The magnetos are waterproofed by enclosing them in a split aluminum case. The joint at the split is packed with sheet rubber packing. The leads are brought out of the case through stuffing glands. The magneto driving shafts are provided with stuffing glands.

The spark plugs are waterproofed by means of a bakelite cap held in place over the plug by a nut which screws onto the brass screw of the plug. The lower part of the cap is turned to a bevel to form a water tight seat on the shoulder of the plug. The wire is molded into the bakelite.

The generator and motor have special heads which are packed to prevent water from entering the case. The armature shafts are packed with a stuffing box.

The generator and starting motor terminals are covered with a water tight case, the leads being brought out of the case through stuffing glands. Waterproofing the carburetor and closing the various openings into the crankcase are yet to be worked out. However, waterproofing has been carried out successfully on other engines and should offer no difficulty here. The feasibility of waterproofing is yet to be decided. Experiments carried out so far indicate that not only must the various auxiliary devices on the engine be carefully protected to prevent the entrance of water, but other parts of the carriage such as transmission case, track roller bearings and other parts must be constructed to prevent the entrance of water. The question to be determined in connection with waterproofing is whether the additional construction necessary is warranted, considering the probable number of times that the carriage will be called upon to enter water during its useful life.

Metallurgical Improvements in the Springfield Rifle

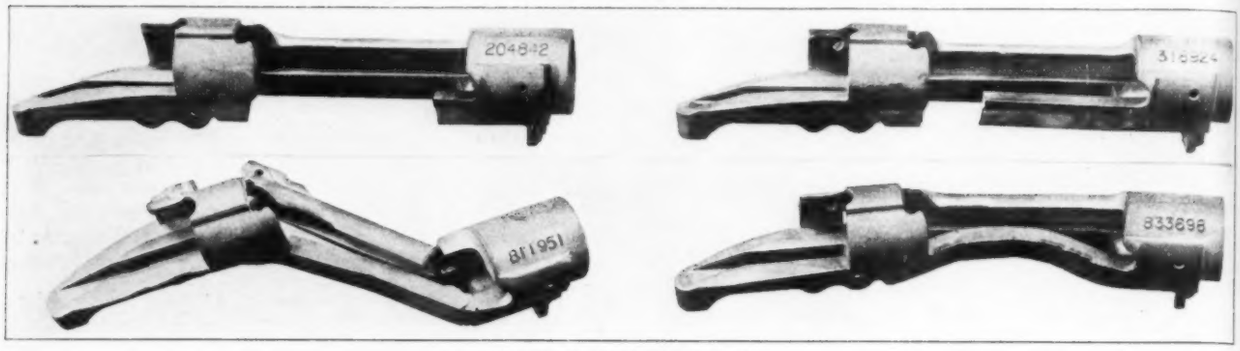
By

JULIAN S. HATCHER

Member A. O. A.

THE Service Rifle is perhaps the most generally known and the most widely used product of the Ordnance Department. It is handled by the entire rank and file of the Army, trained and untrained, intelligent and stupid. It is issued to the Navy, the Marine Corps, and the National Guard. It is purchased by thousands of civilians annually for use in target practice, and when modified and restocked it makes the most perfect hunting arm, and is used by countless sportsmen. Because it is subject to such a wide variety of service, it is bound to be the frequent object of abuse or carelessness which may tax its strength to the utmost. For this reason it must have a higher factor of safety than is necessary for most other classes of ordnance material. For example, compare it with the giant railway artillery produced by the Ordnance during the late war. The rifle is handled by even the most unskilled soldier, while the big gun is handled only by technically trained gun crews. The rifle in the hands of careless personnel may become plugged with mud, or have a cleaning patch left in it, and may be fired in this condition; such an occurrence could hardly take place with a big gun. The rifle is used by thousands of civilian marksmen who reload their own cartridges, and sometimes make mistakes which result in very high pressures; the big gun is subject to no such abuse. We see, therefore, that the rifle must have a much higher factor of safety than the cannon, and that even so, accidents will occasionally happen.

For many years all rifles that have burst in service have been returned to Springfield for examination to determine the cause of the trouble so that steps can be taken to prevent

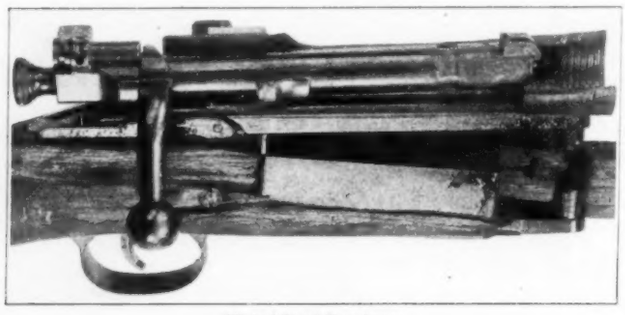


Above: Carbon Steel Receivers
Below: Nickel Steel Receivers

These receivers have been tested by striking them with a hammer. The upper ones, which have the old heat treatment, were easily broken. The lower ones, which had the new heat treatment, bent after severe pounding and the hard outside skin showed surface cracks, but the parts were held together by the tenacious character of the soft core.

a recurrence. Breaks are of two general types, either bursting of the barrel or blowing up of the breech mechanism. There is never any difficulty in finding out the cause of a burst barrel. If the steel is sound, the barrel cannot be burst by any pressure that can be generated by a cartridge, because the barrel is relatively stronger than some other parts of the system. However, burst barrels do occur. The common cause is firing the gun with an obstruction in the barrel. In this case the damage is of a very characteristic nature. It consists of a concentric bulge, or ring, which extends all the way around the barrel. Sometimes the bulge is barely perceptible, and other times the lump is as big as a walnut. The barrel may also be split into several pieces, but in any event the concentric ring is always plainly evident when the breakage is due to an obstruction.

Another cause of burst rifle barrels which is more rarely found in service is seamy stock. As the barrel is a long object, the metal must be forged out into a long bar before the manufacture of the barrel can be started. If there are



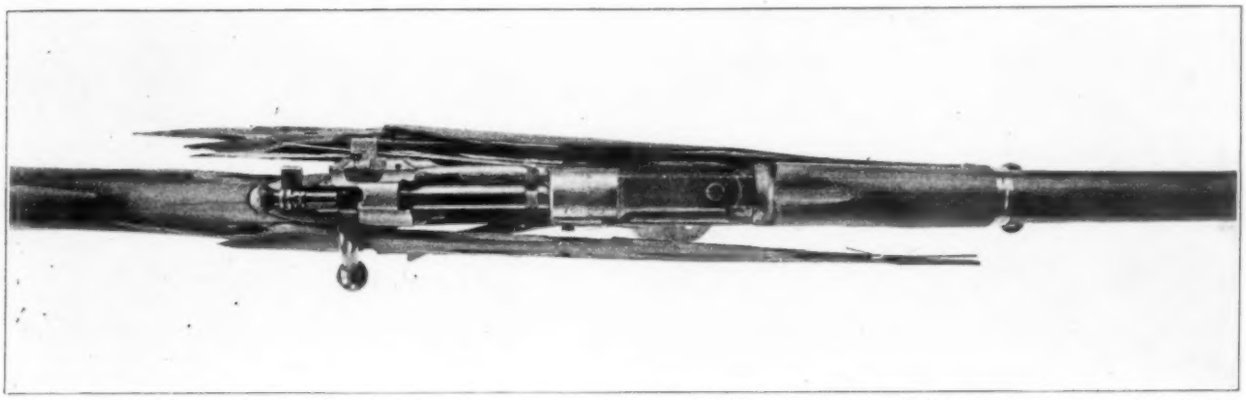
Nickel Steel Receivers

It required 125,000 pounds to burst this nickel steel receiver, which in an excellent record

any flaws in the original billet, this forging operation will draw them out into long streaks or seams. The most of these flaws will appear at one point or another on the surface of the bar, and can thus be caught by inspection. Still, a few such flaws may be entirely beneath the surface, and thus cannot be detected until machining is started, when they will usually be brought to light by either the turning or the boring operation. Once in a great while a seam may be so located that it is not brought to the surface by either boring or turning, and in this case the result will be a weak barrel. To guard against the danger of such barrels being sent out to service, each gun after assembly is subjected to a firing test consisting of five regular cartridges (which give a pressure of 50,000 lbs. to the square inch) and one high pressure cartridge, of 70,000 lbs. to the square inch. By this means the weak barrels are eliminated before the guns leave the factory. It may therefore be assumed that any Springfield barrel that reaches the service is strong enough to stand not only the service charge but also a 40 per cent overload. However, no barrel that can be made will resist the strain of firing the gun with an obstruction in it, and as carelessness will occur, barrels which are burst or ringed by obstructions are sometimes seen. Fortunately, these accidents rarely result in injury to the personnel, as the pieces of a burst barrel usually go forward or sideways, and do not come backward to strike the shooter.

Another type of failure which is far more serious in its results is the breakage of the bolt or receiver, which would allow the entire breech mechanism of the rifle to be blown back into the face of the shooter, with disastrous results. The usual cause of such accidents is excessive pressure due to improperly hand loaded cartridges, obstructions, defective cartridge cases, etc.

While such accidents are by no means frequent, they have in past years occurred with a certain amount of regularity both with the Springfield rifle and with all other types of high-powered rifles. One of the noteworthy achievements of the war period was the complete elimination of such accidents with the Springfield rifle. The work which resulted in this improvement was started by Brig. Gen. W. S. Peirce in 1917, as a result of the examination of three rifles which burst while using a lot of war-time ammunition. The examination of these rifles, which I personally made under the direction of Gen. Peirce, showed clearly that the ammunition, made by a new concern unfamiliar with cartridge manufacture, was defective. The brass in the cartridge cases was dead soft and very weak, instead of having a certain amount of strength and temper as it should have had. This defect caused the heads of the cartridges to rupture under the force of the explosion and allow the gas under high pressure to escape into the well of the receiver, where it had three times the circumferential area to work on that it had in the chamber, which amounts to multiplying the pressure by 3. By experiment it was found that similar results could be obtained by annealing a regular cartridge case so that it would be dead soft and then firing it. While the trouble was thus found to be in the ammunition, it was the desire of the Ordnance Department to do all in its power to strengthen up the rifles, and for this reason a metallurgical investigation was begun. The practice up to this time had been to make the receiver and bolt of steel containing from .30 to .35 per cent carbon and not over 1.30 per cent manganese. After machining, the receivers were



This Springfield rifle was fired with cartridges giving pressures of 90,000, 110,000, 125,000 and 133,000 pounds per square inch without bursting the barrel or receiver or breaking the bolt. The splintered condition of the stock is due to the escape of gas caused by the melting away of the head of the cartridge case at the enormous pressures used.

carburized in bone charcoal at a temperature of about 1600° F. and then quenched from this temperature. The theory of this treatment was that by quenching from the case-hardening temperature, the high carbon skin would be made very hard, while the low carbon core would remain comparatively soft and tough. Instead, the frequent result was that the core, which contained about 35 points of carbon, hardened also and made the piece hard and brittle clear through. Another disadvantage of this method of treatment was that the prolonged heating necessary for carburizing has a tendency to enlarge the grain of the piece and put the steel in a poor condition to resist shock. For this reason, receivers which successfully withstood the strain of proof-firing with the high pressure charge sometimes failed later, when they had become fatigued by the repeated shocks of firing the service charge.

Experimental tests to determine just what these receivers would stand showed that they would hold the high pressure charge of 70,000 pounds, but would fail at about 80,000 to 90,000 pounds. The tensile strength of the material was usually high, but it was unduly subject to shock. The condition may be likened to that of a razor blade, which will show a high tensile strength, but will shatter when struck. For this reason receivers occasionally failed under a very quick but comparatively low pressure explosion, such as that of the guard cartridge, which contains a light charge of quick-burning powder. The strength of the parts was also found to be rather variable, due perhaps to the fact that a furnace operator who failed to follow his pyrometer and use the prescribed heat was not subject to any check.

In order to improve the product, General Peirce installed a system of recording pyrometers (which made a permanent record of every heat) and obtained the services of a competent metallurgist, Mr. A. E. Bellis, under whose personal supervision the subject of heat treatment was rigorously controlled. Mr. Bellis, who during the war was commissioned a major in the Ordnance Department, set to work at once to devise an improved heat treatment for bolts and receivers. In this he was eminently successful. He changed the specifications of the steel so as to reduce the carbon content slightly and hold the percentage of manganese up to a specified minimum, so that the steel now used contains from .20 to .30 per cent carbon and from 1.10 to 1.30 per cent manganese. He then introduced the double heat treatment, which is described below. The first step in the treatment is the carburizing, which is done in rotary furnaces by the gas carburizing method. This process is so regulated that the carbon penetration extends to a depth of about .015 inch, and the carbon content of the skin is about 1 per cent, or over three times as great as in the interior. This means that the high carbon skin will have a critical range about 50 degrees lower than that of the low carbon core. The piece is quenched from the carburizing heat, which is above the hardening point of both the high-carbon skin and the low-carbon core. By this means, the part is hardened clear through. It is then reheated to a temperature above the hardening point of the skin, but *below* that of the low-carbon core; and again quenched. By this means, the high-carbon skin is hardened, but the low-carbon core is annealed and rendered quite soft and tough. This second heat also refines the grain and greatly improves the general physical qualities of the metal. This treatment gives a very hard surface skin which resists wear, and a soft, tough core which resists shock. Before its adoption, this new treatment was tried out in the Experimental Department, and it was found that pressures of 90,000 pounds, which destroyed the old type of receiver, had no effect on those with the new treatment. To find out how much more they would stand was the next step, so higher pressures were tried until the highest pressures available with ordinary powder were used, with no effect. Special high pressure cartridges were then made up with very quick-burning powder, to give the maximum shock. To our surprise, we were unable to rupture the new receivers or bolts with any of the pressures we used, which were 110,000, 125,000, and 133,000 pounds per square inch. With these high pressures the head of the cartridge case was practically melted away, allowing the violent escape of gas which splintered the stock and sometimes blew off the extractor, but neither the bolt nor the receiver gave way.

When the subject of improving the receiver was first taken up, nickel steel was also considered, as it is highly resistant to shock, and was very successfully used by the manufacturers of the 1917 rifle, and by the Rock Island Arsenal for receivers and bolts. It was found that while the nickel steel receivers had a large factor of safety, they could be fractured by pressures around 125,000 pounds, while our new receivers could not. The new heat treatment was, therefore, adopted as standard and put into effect in all Springfield rifles after No. 800,000. In all the 400,000 rifles made at Springfield Armory since, there has not been a single case to date of a bolt being blown out or a receiver being burst in service, which it is believed establishes for the Springfield rifle the right to be called the safest high-powered rifle in the world.

Major Bellis, who did such excellent work on this subject, left the Armory after the close of the war to engage in business for himself, but his work has been ably carried on since his departure by Mr. E. L. Wood, the present Chief Metallurgist of Springfield Armory, and it can be confidently stated that the high standard attained in the past will not be lowered in the future.

Warehouses for Storage of Caliber .30 Ball Ammunition, Mulheim Ammunition Depot

Ammunition Supply in Germany

By

R. L. MAXWELL
Member A. O. A.

THE general subject of ammunition supply was discussed in the January-March, 1921, issue of ARMY ORDNANCE in an article prepared by Major A. J. Stuart, Ordnance Department, and accepting Major Stuart's enunciation of the principles involved, a system of ammunition supply for the American Forces in Germany during the 1921 target practice training period was worked out and put into operation.

A general study of the problem, including Major Stuart's article referred to above, the discussion of that article by Colonel Worcester, the provisions of the Provisional Manual for Ordnance Field Service, and the views and opinions of a number of officers on duty in the American Forces in Germany who saw service during the World War in both line and staff, led to a proposition to try out an extension of the Ordnance Ammunition Supply system during the 1921 Target Season. Several very definite reasons were advanced for making this trial, one of the principal being that during the target season of 1920, a number of rather serious accidents occurred during the firing on the ranges, and when investigated by Ordnance officers it was found that ammunition was, as a rule, issued and fired without regard to lot numbers, making impossible definite identification of lots responsible for the difficulties. Regimental Commanders consulted received the proposition enthusiastically and in conference with the Ordnance Officer, A. F. G., it was decided to try out the plan without reference to higher authority and without having any instructions published from headquarters, which made it possible to revert to the normal method of supply at any time. Following this decision, the following order was published at the Mulheim Ammunition Depot:

GENERAL ORDERS,
No. 11.

ESTABLISHMENT OF BRANCH DEPOTS.

1. In order to extend the Ammunition Service of the American Forces in Germany, a chain of Branch Depots controlled by and operated as a part of this depot will be established in the American Forces in Germany to provide points of contact with troops at all regularly used and operated target ranges. These Branch Depots will be considered a part of the Warehousing Branch, Property Section, Supply Division, and procedure and detailed instructions for their operation will be laid down by the Chief of the Property Section.

2. To provide trained personnel for branch depots, a "Branch Depot Training Unit" will be established at once in the Warehousing Branch and all issues of ball caliber .30 and .45 ammunition will be made through this unit. The military Personnel Section will assign personnel to this unit as directed. Branch depots will be established by General Orders issued by this office and personnel assigned and transferred by Special Orders issued by this office.

R. L. MAXWELL,
Major, Ordnance Dept., Commanding.

At this point it is desired to emphasize the fact that throughout the trial it was the policy to definitely assign each individual a place in the scheme of supply and require him to work out his methods, issue his own instructions, to put his plan into operation. It is believed that this policy fixed responsibility where it belonged and eliminated a great deal of overhead publication of orders. Following the publication of the General Orders quoted above, the Chief of the Property Section, Technical Sergeant, published a concise but complete memorandum setting forth the detailed procedure to be followed in making issues of ammunition through the branch depot system.

It is admitted that higher authority could very probably have published better orders from the standpoint of English, but it is doubted if the effectiveness of orders under those circumstances would have been equal to that of orders published by the technical sergeant.

It was decided to send out two men, a private (first class), and a private, if available, to each branch depot, and the first pair were assigned to the Branch Depot Training Unit.

The Branch Depot Training Unit set up a branch depot in the storage area of the Mulheim Depot and made issues and receipts of caliber .30 and caliber .45 ammunition, kept records, and submitted reports and papers to the Property Section. Errors were made and points to be emphasized were discovered during the training period.

Personnel were relieved as needed for assignment to the branch depots as established. The length of time in training varied from one to ten days, but even the one day of training received by some of the men assigned was of great benefit and prevented many errors and saved time and effort in the long run.

In order to establish branch depots at the right place and at the right time, regimental and equivalent commanders were visited by the Commanding Officer of the Mulheim Depot or a commissioned representative and a schedule of places and dates agreed upon. Regimental commanders were asked to accompany the depot commander to the ranges to fix in detail the location of the depot, but in general the decision in that matter was left to the depot commander after consultation with the range officer. The importance of visiting the regimental commanders and letting them say what they needed and when needed cannot be overestimated, as the few minutes spent in these visits served to fix the status of the depots on the ranges and settled in advance many questions that could and unquestionably would have arisen had the establishment of depots been undertaken without this personal contact with the responsible commanders of the larger units to be served. It was agreed at those conferences that troops would furnish guards for the depots, that depot personnel would be attached to a unit for quarters and rations, and that the range officers would, as a rule, prescribe the hours branch depots were to be kept open. Throughout, the idea was impressed upon every one concerned that the object of the scheme was to improve the ammunition service to the firing troops and at the same time to reduce to a minimum the responsibility of the troops for maintaining a supply of ammunition that was serviceable and safe to fire insofar as it was possible for the Ordnance Department to determine in advance.

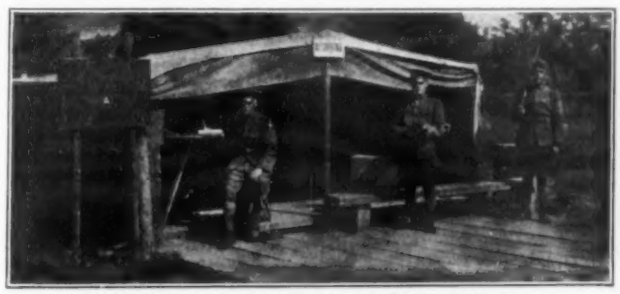
Having obtained a schedule of requirements from the regimental commanders, proposed branch depot sites were inspected by the depot commander, the range officer, or commanding officer of the unit of troops to be served, and an energetic young sergeant, who had been especially selected to establish and operate the branch depots. Having selected and decided upon the site, Depot General Orders were issued establishing the depots.

Having published these orders, the sergeant in charge established the depots on the site selected and opened up

Truck loaded with ammunition, leaving warehouses, Mulheim Ammunition Depot, for delivery to Branch Depots

for business on the date fixed in the orders. As a rule, the branch depot consisted of a bridge-plank platform covered by a tent, tent fly, or salvaged paulin and was located on the flank within 100 yards of the 400-yard firing point, if possible. It is interesting to note here that range officers usually suggested the range house near the target butts as the site. As this was generally inaccessible during firing from the firing points, it was discarded and a building in a nearby town offered next, but no depots were established or operated in towns or posts except those serving Field Artillery or Machine Gun organizations. In case of the Field Artillery and Machine Gun units, caissons and belts were filled directly from depots established in isolated buildings in the organization compounds. Rail, motor and wagon transportation, obtained from various sources was used, rail movements being made whenever practicable.

Depot personnel were given orders to issue direct to



Branch Depot and Personnel, at Target Range, Vielbach

organizations firing without requisition, ammunition for immediate use, and to receive from organizations firing (1) unserviceable ammunition, (2) fired cartridge cases (3) empty bandoliers, and (4) packing cases. It was emphasized that the function of the branch depot was to supply ammunition to troops for immediate use and as near the firing point as possible, and that the depots as such had no interest or responsibility in matters of amounts expended or the propriety of expenditures, all questions of allowances, expenditures, amounts of material to be turned in having been fully covered in regulations. Orders issued by competent authority could not be changed, modified, or set aside by the branch depot.

A total of seventeen branch depots were put in operation and during the period from the first of April to the fifteenth of June issued a total of 7,000,000 rounds of caliber .30 ammunition and 500,000 rounds of caliber .45 ammunition. It is understood that the caliber .30 ammunition was, during the remainder of the training season, increased to something over 10,000,000 rounds. Throughout the operation, especially during the first month, inspections were made by the depot commander and the sergeant in charge of branch depots as often as time and transportation facilities permitted. In no case, however, was one branch depot visited by the depot commander more than four times. During these inspections, action was taken on all cases of non-compliance with instructions or procedure unsatisfactory to the troops being served, and officers in charge of firing on ranges were asked for complaints or suggestions for improvement of service.

Considerable stress was laid upon the neatness and orderliness of the depots and the military bearing of the personnel. Deficiencies noted during these inspections were published in the form of memoranda for circulation among the other depots for the information and guidance of branch depot personnel. The high standard of orderliness, cleanliness, and neatness established and maintained merited and received the favorable comment of all troop commanders and staff personnel.

All cases of malfunctioning of ammunition of any nature whatsoever were reported directly to branch depots, the branch depot personnel taking such action as they were able to take and reporting facts to the depot commander. It was soon found that one good man could handle a

branch depot satisfactorily, and an effort was made to provide privates first class or privates with the sixth class specialist ratings for all depots. As a rule the men liked the assignment and it was possible to fill the positions with selected men. Many of the men showed unexpected initiative and on the whole the business-like air of the establishments was a distinct credit to the Ordnance Department.

From the standpoint of training Ordnance troops, especially ammunition companies, in time of peace, it is not believed that a better plan could have been devised, and it is felt that there is not an officer or man in the Ordnance Ammunition Company which furnished the personnel for this tryout who is not better equipped to handle the work of a field ammunition depot under any circumstances than he could possibly have been had he undergone any other kind of training during the time devoted to the operation of these depots We all gained first-hand knowledge of what the fundamental requirements of the problems are on a small scale and have that much of a start when we are called upon to handle similar problems on a larger scale. We feel confident that we have successfully demonstrated that the Ordnance Department can take the field and carry its ammunition supply service beyond the stopping point laid down in the present approved solution of the problem of ammunition supply, and that by so doing the needs of firing troops can be looked after by an impartial branch of staff troops equally interested in supplying all branches of firing troops. It is also believed that comparison of the number of officers and men involved in this phase of active operations with the normal system will show that the handling of the ammunition supply problem by Ordnance troops consumes less officers and men. Line officers may regard as a disadvantage line organizations being relieved of the responsibility during peace activities and contend that we are stealing the opportunity rightfully theirs to train their own supply troops in the handling of ammunition. However, we appreciate the opportunity given us to demonstrate what we could do, and as Major Stuart indicated in the closing paragraphs of his article, force of circumstances may compel similar action in the next war.

In conclusion, results may be summed up as follows:

(a) The ammunition supply service was extended to companies firing on the target ranges,

(b) Paper work connected with supply of ammunition was cut in half and all requisitions were eliminated,

(c) Companies were enabled to fire from a single lot of ammunition at a time,

(d) Lots of ammunition showing up badly or found to be unserviceable during firing could be withdrawn and replaced by a new lot,

(e) Company, Battalion, Regimental and Brigade Commanders were relieved of the responsibility of checking ammunition to see that no condemned lots were being fired,

(f) Ordnance Ammunition personnel of the American Forces in Germany received a maximum of training possible in time of peace, in the issue, including transportation by rail, motor, and wagon transportation, and inspecting of ammunition being consumed by using troops.

Long Range Small Arms Firing

PART VII—Continued

Boat-Tail Bullets

By

GLENN P. WILHELM
Member A. O. A.

HAVING considered in a previous article the experimental and theoretical side of boat-tail bullets, it is now desired to discuss the practical questions which come up as to whether such a long ranging, flat trajectory type of machine gun bullet, such as the boat-tail bullet, is really tactically sound.

To the majority of persons, both military and civil, this will probably come as a complete surprise, as nearly every one is positive that flat trajectory and range in ammunition are more desirable than almost any other feature. However, strong opposition was encountered when it was proposed to adopt such a type of bullet for Infantry machine gun use as will be shown presently. It has been difficult to decide upon an improved machine gun bullet due to conflicting views regarding just what constitutes an ideal machine gun bullet.

The principal reason the development of an improved machine gun bullet was instituted was because of the fact that the Browning Machine Gun with service ammunition was considerably outranged by the French Hotchkiss. The A. E. F. particularly requested a long ranging bullet of a type similar to the French. Recommendations were insistent upon the importance of range, even at a sacrifice of accuracy, and it was stated that the only way to obtain this was by increased weight and a boat-tailed base, which is true. Pursuant to these recommendations, the experiments were directed along this line, which resulted in the firing of the Swiss bullet and the development of a bullet which it was thought would easily qualify as an improved type of machine gun bullet. It, however, was not similar to the French because of the objections to this bullet which have already been stated in the preceding article.

As has already been stated, the Browning Machine Gun with service ammunition can only be considered effective to about 2500 yards. However, with the boat-tailed bullet, its effective range on this basis is at least 5000 yards, or double that with the service bullet. The French Hotchkiss is effective to a range of about 3500 yards. Of course, these figures are based on the ballistics of the bullets and not on their tactical use.

Comparing the trajectories it was found that at ranges less than 800 yards, the Browning with service ammunition

and with the boat-tail bullet are about the same, both being considerably flatter than the French. However, at ranges greater than 1200 yards, the Browning with the boat-tail has the flattest trajectory, the next being the French Hotchkiss and the highest of all being the Browning and service ammunition.

Apparently then, a bullet had been developed which gave to the Browning Machine Gun a range much greater than the French Hotchkiss and without the corresponding disadvantage of excessive weight of the bullet and length of barrel of the gun. However, opposition to the adoption of this type of bullet was advanced to the effect that "tactically" this bullet was not wanted as its trajectory at indirect fire range was so flat that troops could not advance under cover of its fire as closely supported as could be done by the use of service ammunition, and that the increased range was of no tactical use whatsoever, as it could not profitably be employed in battle due to the limitations of the accuracy in maps, fire control instruments and tables, and lack of observation.

The ideal machine gun bullet which was considered to meet the tactical requirements was to have the following qualifications:

First: At ranges up to about 1,000 yards its trajectory should be similar to service ammunition.
Second: At ranges of about 1,000 to 2,000 yards (indirect fire ranges) its trajectory should at least be higher than the French and preferably even higher than service.
Third: It should have an effective range of at least 3,500 meters.

Of course no such bullet is possible, although it was pointed out by the opposition that if the boat-tail bullet had too great ranging ability with too flat a trajectory it should be possible to increase the height of trajectory by decreasing the range through changing the shape of the bullet so as to increase air resistance.

The fallacy of this argument lies in the fact that any change in the bullet affects the entire trajectory and such a proceeding as outlined would also increase the height of the trajectory at short range. Any two of the three conditions can be met but the bullet has not yet been designed which will travel flat for the first third of its flight, travel high for the second third, and then proceed to travel flat again to its extreme effective range.

In order to facilitate the solution, the third requirement was finally reduced to 3500 yards (3200 meters), but this did not materially help matters. About the only bullet which will give a short-range flat trajectory and a mid-range high trajectory is the present service bullet, as its high velocity, light weight and flat base are admirably adapted to lose velocity rapidly and thus require the greater elevations necessary at mid-range in order to get the desired height of trajectory.

The advantage of the boat-tailed bullet for machine gun use in general is that it increases the length of the danger space at all ranges, thus increasing the probability of hitting due to minimizing the importance of range finding, sight setting, etc. Its advantages in detail are:

A. Slightly flatter trajectory at even the shortest ranges than the present flat trajectory service bullet.
B. Length of effective range at least 5,000 yards,—of great tactical value in the following respects:
(a) Harassing fire on which more targets at greater ranges can be engaged.
(b) All forms of covering fire by long range machine gun fire.
(c) Much greater choice of desirable positions from which to go into action.
(d) Enemy's trench mortar bombardment zone can be avoided when necessary.
C. It can be used in the rifle at short range with practically the same elevations that are used for service ammunition.

The disadvantage of this type of bullet is that in general it limits the use of indirect overhead machine gun fire at midranges on comparatively level terrain. Specific objections to the adoption of the boat-tailed bullet for machine gun use were based on the following reasoning:

For direct machine gun fire support to leave the target while the Infantry is 600 or 700 meters from its immediate objective is a matter of too great importance for dismissal in favor of an extreme range of very doubtful value.

It is hoped and highly desirable that the 500 meter distance permissible with the 1906 ammunition can be reduced. Direct machine gun support should be greater in the future than in the past, and the effectiveness of this support will increase with the closeness to which our own troops may safely approach the supporting machine gun fire. Any lengthening of this zone should be approached with great caution, as it is a step in the wrong direction.

It can be shown that these are ideal conditions and that as a theoretical proposition this is desirable but that practical considerations make it of doubtful value. For instance, the use of direct over-head fire is usually confined to ranges not greater than about one thousand yards. Due to the flatness of the trajectory of all types of military ammunition at these ranges, this fire can not be executed except on suitable terrain. The boat-tail bullet can be used for this fire just as satisfactorily as the present service bullet and in no case can any type of bullet give "direct machine gun fire support" on horizontal ground. On the other hand indirect overhead machine gun fire support is usually used at ranges from about 1000 to 2200 yards. Based upon the length of the horizontal dispersion and the lowest shot of the machine gun cone of the vertical dispersion, troops on or near a horizontal plane using service ammunition can get within approximately 500 yards of their target; while with the boat-tail bullet the nearest the troops can approach the target will be about 700 yards, depending upon the range. It is upon the above comparison that most of the objection to the boat-tail bullet is based.

This, however, is not a fair comparison of the relative danger of the two types of bullets for overhead fire, as, due to the inferiority of service ammunition at ranges beyond 150 yards, troops might possibly be more closely supported without danger to themselves by the boat-tail bullet than with the service bullet, and at the same time the target would probably be more effectively covered with fire. Moreover, the importance of this comparison has been over-emphasized as it is necessarily confined to comparatively level terrain in order to show the boat-tail bullet at such a disadvantage. Also it must be borne in mind that fire which is safest for our own troops (for purposes of overhead fire) is the least dangerous to the enemy, for the danger zone is greatly decreased as the trajectory becomes more curved.

While the height of the trajectory of service ammunition at a range of 2000 meters is nearly twice as great as the trajectory of boat-tail ammunition at the same range, which of course allows the attacking Infantry to be more closely supported on this basis alone, yet the wind has approximately 50 per cent more time to affect the light 150-grain bullet than it has to work on the heavier 175-grain boat-tail bullet.

As far as the length of dispersion on the horizontal or the depth of dispersion on the vertical are concerned, the present safety angle for service ammunition is entirely too great, but it is doubtful whether it can be decreased, due to the fact that the entire cone of fire may fall short and endanger the attacking troops. If the center of impact of the beaten zone were always known then the attacking troops could advance in safety to within probably half the distance to which they are now allowed to approach. The present method of computing safety angles is based upon

the location of the center of impact, which can never be determined under service conditions unless improved methods of observation are developed such as the use of "spot light" bullets.

In addition to the weight attached to the importance of indirect overhead fire on level ground, it is assumed that the present table of safety clearance is satisfactory, although the system by which the present table is compiled was originally determined for service ammunition by using the former computed values which made service ammunition have as flat a trajectory at mid-range as French ammunition. If this table was satisfactory on that basis, why cannot the French trajectory curve be taken as a standard, considering that the dispersion of French ammunition is much greater than any of our own?

The A. E. F. did most of their indirect firing with French guns, French ammunition and French tables. Why is it now necessary to insist upon a trajectory curve which is higher at mid-range than the French even though the new ammunition has less dispersion? If the present distance on horizontal ground between the attacking troops and the fire of the supporting troops is already too great and should not be increased, then it would be impossible to use indirect fire with French ammunition and French machine guns, although a communication from the French Military Attaché to General March shows that after a careful study of the lessons of the War the French intend to retain their present long-range type of bullet.

Moreover, it will be impossible to adopt any other type of bullet than the present service type, as all other types of military bullets have a flatter trajectory at mid-range and no first-class military nation at the present time has as steep a trajectory as the United States has at the longer machine gun ranges and it is not believed that any contemplate adopting a bullet with a steeper trajectory.

During the war the Germans were always quick to borrow ideas from the ordnance of other nations. They not only used rifle ammunition having the flattest trajectory at short ranges but in the latter stages of the war developed a long range ammunition for their own machine guns and also for use in captured French guns, which had a still flatter trajectory than the French Hotchkiss at all ranges.

Therefore, at least some battles were fought with long range machine gun ammunition on both sides (the French Balle D and the German Long Range Gun Bullet), which on the basis of comparison on level ground would have required indirect machine gun fire support to leave the target while the Infantry were 600 or 700 meters from its immediate objective, and despite this fact it was not considered important enough to warrant the adoption of higher trajectory ammunition by any of the great powers.

Moreover, the objections now advanced to the lack of necessity for the great range now attained by the high velocity boat-tail bullet are the same arguments which military conservatism has always advanced in turn against the original introduction of firearms, breech-loading, repeating action, smokeless powder and high velocity rifles. If the fire control instruments and means of observation at present are incapable of making use of this great effective range, this is not a sound reason why the effective range should be restricted by limits in other equipment. Would the Artillery hesitate about adopting projectiles going twice as far with the same expenditure of energy that the present projectiles require, merely because fire control instruments had not been perfected to make use of it or tactics created for applying it? History shows that once an improvement is made in a mechanical device, little or no difficulty is experienced in improving everything else up to the new standard that has been established.

It is contended that the failure to adopt an ammunition having the points of superiority obtained with the boat-tail bullet merely because, on a basis of comparison with service ammunition under a condition which but rarely occurs, it proves to be inferior, is of doubtful expediency in view of the facts as shown by the data. Moreover, the adoption of an ammunition having a much lower velocity and a much higher trajectory than the ammunition at present in use by the leading military nations is a distinct backward step. If the importance of indirect overhead fire is so great as to justify the rejection of the boat-tail bullet merely because on comparatively level ground it would be dangerous to the Infantry to advance within 700 yards of its own machine gun barrage unless the guns were in position far enough in the rear to secure a curved trajectory, then it appears as if a special weapon should be designed to offer support to the advancing line up to the moment it actually reaches the target, particularly in view of the fact that even the present service ammunition leaves the Infantry line unsupported for at least 500 yards before the target is reached.

Improved Ammunition for both Rifle and Machine Gun

The remarkable success of the Small Arms Division of the Ordnance Office and Frankford Arsenal in producing for the last two years National Match ammunition which has had phenomenal accuracy for machine loaded ammunition has resulted in a demand by the service for similar ammunition. National Match Ammunition has been standardized around a weight of 170 grains and a muzzle velocity of about 2600 f. s., the bullet being flat based.

Recent tests of the 1922 National Match Ammunition with improved boat-tail bullets made by Frankford show that it is possible to manufacture such a type for the rifle which is even superior to the best of previous match ammunition. For the rifle the most important characteristics ballistically are accuracy, flatness of trajectory and lessened wind effect within rifle battle ranges (1000 yards). This is assuming that the necessary shock effect is retained. Up to the present time, to obtain all of these characteristics the flat based bullet had to be used, as the greatest possible accuracy could only be obtained with such types. As machine gun ammunition does not require as high a degree of accuracy as rifle ammunition, one of the solutions of the problem, in case boat-tailed ammunition could not have been made very accurate, would have been to have adopted the boat-tail for machine gun use and the flat-base for rifle use inasmuch as in an emergency they are interchangeable.

Or if it is true that the tactical advantages of a higher trajectory at machine gun mid-range more than outweigh the desirability of a flatter trajectory at the same ranges and at much greater ranges, then the obvious answer is to adopt a flat-base National Match type of bullet for both machine gun and rifle use. This ammunition, while it will not meet the requirements as to height of trajectory as it is much flatter at mid range than service, will come nearer to fulfilling the conditions than will the boat-tail. It is not so flat as the boat-tail, and has a much shorter range, yet it is a considerable improvement over service ammunition in these respects.

The development of the boat-tail bullet so that it gives all the accuracy desired for the rifle and still gives the ranges demanded for the machine gun makes it possible for the Infantry to adopt this bullet for both weapons.

Standardization of Rifle and Machine Gun Ammunition

It will be noted that all of the types of ammunition proposed for both rifle and machine gun are standardized around a bullet weight of about 170 grains and a muzzle velocity of 2600 to 2700 feet per sec. This will simplify manufacturing problems and design and particularly facili-

tate the use of such ammunition in action due to the trajectories and consequently the sight settings being more nearly the same than would be possible with bullet weights and velocities of considerable variations.

The question of barrel life for the machine gun has not been discussed, although it is extremely important. This is because it depends mainly on the type of powder used and on the velocity given the bullet, and is about the same regardless of the shape of the bullet itself. However it may be that, in order to lengthen the life of the machine gun barrel, the ammunition for machine guns may be given a considerably lower velocity than that used in the rifle. Of course this would result in an increase in the height of trajectory and some decrease in range, which is a step in the right direction if tactical considerations require such changes.

One other complication will arise in the solution of the ammunition question in case it is necessary to reduce the present caliber in order to obtain in the future a self-loading rifle. While at first, on account of the difficulty of manufacture, supply and tactical policy, only a limited number of all Infantry troops will be automatic riflemen, yet it is evident that eventually all Infantrymen will become automatic riflemen. Thus there will result two calibers of ammunition, one for the present rifle and machine gun, and one for the future self-loading rifle.

Such a difficulty can only be avoided by either using a reduced caliber for all Infantry rifles, including the self-loading type, or by using the present caliber for both weapons. The latter solution depends upon the successful development of a practical self-loading rifle of .30 caliber for the present service cartridge or proposed cartridge using one or more types of National Match bullets, while the former solution involves the sacrifice of all the advantages enumerated as occurring with the adoption of the proposed National Match type of rifle ammunition. A service test of both types of bullets, i. e., National Match types of flat-based and boat-tail bullets, will eventually be held at the Infantry School, Fort Benning, Ga. The type or types adopted will depend upon the results of this test and the relative advantages and disadvantages shown by each type. The present consensus of opinion among the machine gun experts of the school is to the effect that a long range type of bullet such as the boat-tail is decidedly an advantage in spite of its flatness of trajectory at mid-range.

Conclusion

The solution of the problems of future small arms ammunition is rendered doubly difficult by the numbers of factors involved, many of which are of such an inconsistent and contradictory nature as to preclude the possibility of the final choice being successful from every standpoint. Whatever type of ammunition is finally selected must necessarily be an arbitrary decision which will include the majority of the tactical requirements as formulated by the tactical doctrine or policy of the period in which selection is made.

There is no absolute test to determine decisively the wisdom or lack of wisdom in the adoption of an article of armament. War is not necessarily the final arbiter as it is so often declared to be. Weapons which fail in war often later prove to be the most successful. The most familiar examples of this are evident in the evolution of the rifle and machine gun. Weapons and their ammunition fail in war for two reasons, i. e., either from mechanical causes or from wrong tactical uses. Examples of the former are seen in the early failure of breech-loading and repeating systems which were too far ahead of the general mechanical knowledge of their day. A striking instance of the failure of a valuable piece of armament, through a wrong tactical conception, was the general lack of success attending the machine gun in the Franco-Prussian War, which for over a quarter of a century doomed this weapon to oblivion, because it had failed in war.

On the other hand, battles and wars are not necessarily lost and won on the merits of the rifle and machine gun bullet. While the Russians in the Russo-Turkish War of 1877 were worsted in the majority of their engagements with the Turks, due to the great superiority of the American Peabody Martini rifle, with which the Turkish troops were armed, over that used by the Russian troops, any modern type of military rifle and bullet would prove successful in a modern army, other things being equal.

American successes in the World War with service ammunition prove that, although this ammunition can be improved as can the ammunition of any other nation, it can by no means be considered as a handicap and is not so easily improved upon, as the following summary will show:

First: Service ammunition is a good "compromise" ammunition for both rifle and machine gun.

Second: For the rifle it possesses neither the greatest accuracy nor the most effective stopping power which requires a heavier bullet. Yet at the same time even service ammunition is capable of wounding at much greater ranges than the rifleman will ever be called upon to use in battle. Thus he is carrying around a heavier ammunition and rifle than necessary. Therefore the caliber can be reduced and a lighter bullet used. Obviously the weight of the bullet can not be increased and decreased at the same time. The most important requirement must affect the decision.

Third: The self-loading rifle may necessitate the sacrifice of range, accuracy and stopping power for flat trajectory at short range and the advantages that accrue with increased rate of fire and effect and light carrying weight.

Fourth: Rifles and machine guns do not necessarily require the same type of ammunition, due to difficulty in manufacture and the fact that separate and different means of packing and supply are essential and particularly because of different tactical uses.

Fifth: The machine gun on account of the dispersion factor does not require the accuracy of rifle ammunition. It does, however, require much greater range, even though its chief use is similar to the rifle, in that it is at short ranges. However, the machine gun can be used effectively at the longer ranges, particularly in support of troops. It will, therefore, require the same characteristics as rifle ammunition at the shorter ranges and yet must have greater stopping power at the longer ranges. Increased danger spaces are important for the machine gun at all ranges. This fact, together with the necessity for increased stopping power, requires a flat trajectory at all ranges.

Sixth: The machine gun also requires ammunition with a height of trajectory sufficient at mid range to properly support troops on comparatively level terrain. Obviously, an ammunition can not have the flat trajectory necessary for increased danger space and stopping power, and yet at these same ranges have a high trajectory for clearance of troops. A decision will, therefore, be required of the tactician as to which tactical requirement is the most important considering that while long ranges may not be important or even that covering fire at mid ranges has been over-emphasized, yet stopping power at all possible ranges is the primary consideration.

Whichever way the decision is made, it can be depended upon to select an ammunition which will achieve decisive results, for it must be remembered that an ammunition which may be inferior in range, for instance, will at the same time be superior in some other important characteristic more in conformity with tactical doctrine, and that by proper training and instruction such a type of ammunition will be the best possible under those conditions. In other words, the weapon will fit the tactics (or vice versa) and there will not be seen the ridiculous fiascos often found in previous wars where ammunition capable of out-ranging enemy ammunition was used only at ranges within which the enemy's was also effective or attempts to use ammunition at ranges obviously too great for its effective use.

Artillery Ammunition Development

By

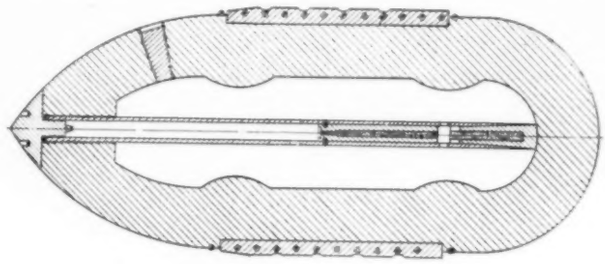
ARTHUR ADELMAN

Member A. O. A.

MANY years ago the following statement was made by an inventor of guns and projectiles appearing before a Select Committee on Heavy Ordnance and Projectiles, following long discussion on gun construction: "All I have to say in regard to the subject of projectiles is that pretty much all that can be done in projectiles has already been invented. . . . There is no further invention open to be made in projectiles. . . . We can easily make the projectiles. I know all about them; they are all invented; but the point is to get the guns, etc." While this is a much exaggerated view, it nevertheless shows the general attitude on the question of ammunition development, namely, that the ammunition can be supplied without any particular difficulty or previous development.

At the present time there appears to be a more or less fixed impression in the lay mind that due to the large stock of artillery ammunition which we have accumulated as a result of the war production, it will be unnecessary to continue development work on new types or to maintain facilities for the testing of either new or old types. The idea appears to be that a holiday may be taken for a period of years during which this stock of ammunition is estimated to remain in serviceable condition, and to again take up work when it becomes unserviceable. The impression that this action is warranted is probably based upon the assumption that the ammunition is new and should therefore be of modern types and that the metal parts should practically never deteriorate while the explosive elements are relatively stable and should remain in good condition for a considerable period—ten to twenty years or more.

The assumption relative to the length of time which explosives will remain in good condition is based on the best quality explosive, representing laboratory or peace-time production in small lots and by experienced manufacturers. As a matter of fact, even under these conditions, not every lot of explosive produced will come up to the specified requirements even with the most careful inspection practicable. No specification has yet been devised, and probably none will ever be devised, whereby every lot of explosive which does not come up to the standard can be determined. These lots will only be detected after a period of storage. Deterioration is a progressive action and may start almost immediately after manufacture, and only continual observation and occasional firing tests will determine which lots

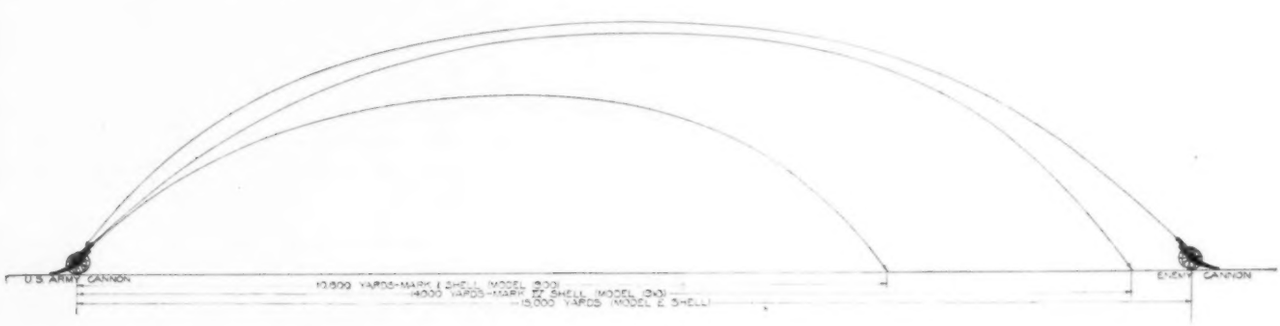


"Perfect" Projectile: Patented May 1, 1860

have reached such stage of deterioration that they should be isolated from good lots and disposed of.

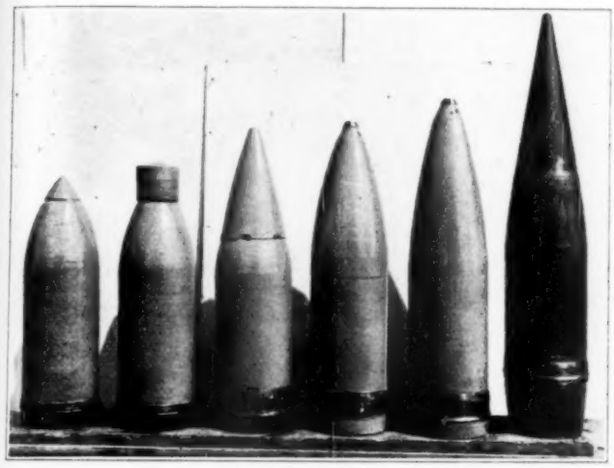
With the war-time production of ammunition, which covers practically all that is now on hand, the chances of early deterioration are multiplied many times. In the first place, we have new explosives with which there has been no previous experience, production was required of every possible manufacturer regardless of previous training and experience, new processes of manufacture were introduced and there was a let-down in the rigidity of specifications in a number of ways in order to obtain material in the quantity required. In other words, this ammunition was all produced for the specific purpose of fighting a war which was at hand and for which there had been little preparation, and not for the purpose of providing the most satisfactory reserve for some future war.

This ammunition is the best that could be produced under the circumstances and was satisfactory for its mission. It can, however, by no means be considered as a safe and satisfactory reserve supply for any great length of time.



Trajectories of Latest Type 75-mm. Gun, Using Mark I and Mark IX Shell as Compared with Enemy Using Same Gun Firing Shell Model E-1

There must be constant examination and firing tests with a view to weeding out the bad lots. These bad lots will be of two distinct types, those which are unsafe to the user due to large percentages of prematures or inaccuracy which will make it dangerous to fire over friendly troops and



6-Inch Projectiles
Models 1898, 1903, 1910, 1917, 1918, 1919

those which are ineffective due to large percentage of "duds." The two problems to be met are safety to the user and effectiveness against the enemy.

The upkeep problems in connection with the ammunition of war production are not confined to that produced in this country. Definite information is at hand that similar problems are being encountered by not only the allied countries, such as England, France and Belgium, but that the Germans encountered similar difficulties even before the close of the war. In fact, the upkeep of our small stock of pre-war ammunition, all produced under the most rigid specifications, was a considerable problem. Present difficulties with our larger stocks produced under war-time conditions are, therefore, not surprising.

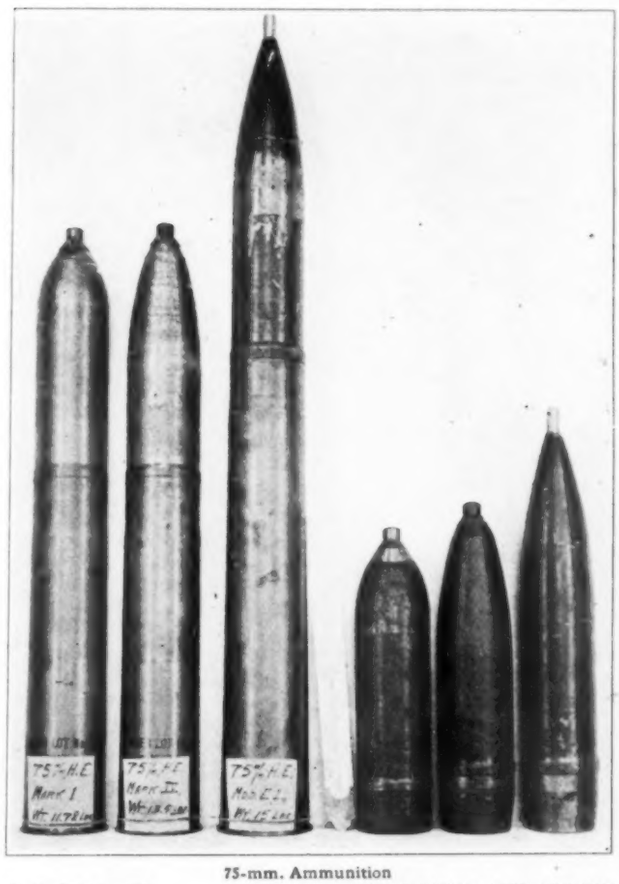
There are so many conditions which may require investigation that it is impracticable to enumerate all of them, but it may help to visualize matters if a few of these circumstances are specifically enumerated. We have in a round of ammunition the following main components which may give trouble in service:

The fuze
The shell
The shell filler (high explosive)
The propelling charge (smokeless powder)
The primer

The fuze may either produce prematures or fail to function, resulting in "duds." Both are ineffective against an enemy and the first is directly dangerous to the using service. The shell may produce prematures by breaking up under the shock of firing or may be inaccurate due to faulty assembly or design of the rotating bands or other causes not always detected during inspection. The shell filler may cause prematures or fail to explode either from faulty or deteriorated explosive material or from faulty loading. The propelling charge may deteriorate so as to give very erratic action, resulting in lack of accuracy in ranging or it may produce dangerously high pressures causing loss of life and artillery matériel. It may also deteriorate to such an extent as to be dangerous in storage. The primer may deteriorate so as to fail to function.

The occurrence of any one of these things would result in making the lot or lots of ammunition which contained the defective component entirely unserviceable. With the large number of different lots of each of these components, manufactured by inexperienced manufacturers and under specifications placing quantity as the primary requirement, it can readily be seen that the upkeep of this ammunition must entail the expenditure of considerable sums of money to sort out dangerous and unserviceable lots. This can only be done by firings at a proving ground equipped to take the various measurements. Any policy which does not contemplate this rigid inspection of the ammunition on hand and periodic firing tests to detect unserviceable lots will result in loss of life due to explosions in storage, and during firing in service. This will render more or less useless the entire supply of ammunition which is being considered as the war reserve. It therefore appears that even without any new development program, there is decided need for a proving ground equipment and manned to conduct the various tests and for the various Technical Services required to inaugurate these tests and determine the action required.

Consider now the subject of the development of improved types of ammunition. It is true that with the necessary supervision and upkeep which undertakes to detect and replace defective components, the large supply of reserve ammunition can be kept in a more or less serviceable condition for a number of years. The design of this ammunition is, however, already largely obsolete, as indicated by the advancement made in the art whereby greatly in-



75-mm. Ammunition
Assembled rounds — Shell, Models of 1900, 1918, 1920
For Guns, Models of 1897, 1897, 1920

creased safety, range and accuracy can now be obtained by suitable improvements. As a matter of fact, most of the designs are either old or hastily prepared and never perfected. The majority of the 75 mm. shell on hand is the

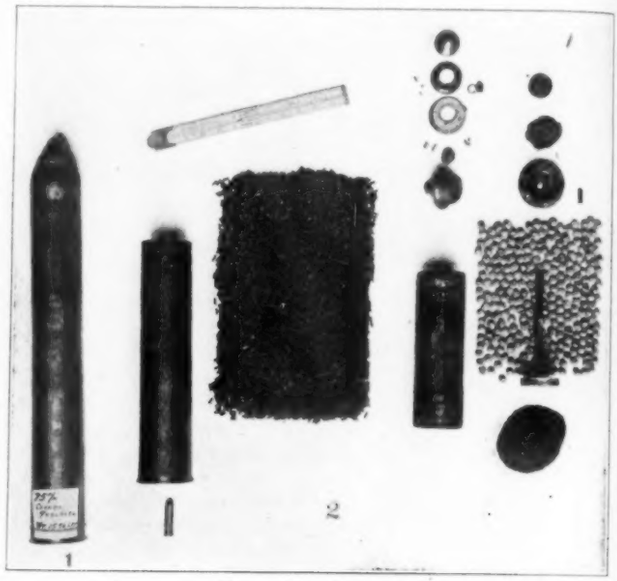
French type Model of 1900 and the fuzes are Model '99-'08 or Model 1916, either old or developed during the war emergency.

We can get an idea of how this ammunition either now compares or will compare with first-class ammunition ten or twenty years hence by comparing an automobile of 1900 model or a 1910 model with a 1920 model, or the factory or office equipment of 1900 with that of 1920, or the ox team on a farm with a modern tractor. However, we need not go outside the ordnance field for our comparison. We have but to consider that, due to improved projectile design during the years 1917 to 1919, the range of one of the guns in our service has been more than doubled and that future improvements of equally startling proportions are not improbable. If we then depend upon our present stock of ammunition to safeguard us in the next war, we are likely to find ourselves outranged by the enemy from 50 per cent to 100 per cent even though his artillery is no better than ours. We will then be in the same position as the Belgian forts were against the Big Berthas (42 cm.), simply targets of an enemy against which we will be unable to fire an effective shot. The Belgian forts are excellent examples of antiquated defenses being attacked by modern equipment. They were simply outranged and destroyed without being able to inflict any damage.

It is recognized in every line of endeavor that equipment must be remodeled and replaced. Organizations which fail to heed this natural law drop out of competition. We have it in our offices, in our factories and on our farms. It is necessary to gradually replace all equipment and this necessity exists whether the equipment is worn out or simply becomes obsolete. We recognize this principle in our Navy where vessels when built are placed in the first line and gradually displaced by more modern equipment to the second line, the coast defense or training vessels, and back to the scrap heap in from about 20 to 25 years. Vessels commissioned about 1896 were being shot to pieces as targets even before the Armament Limitations Treaty and ships of much later date were considered practically useless. Why not then recognize this principle in our reserve ammunition and keep the old material in as good repair as practicable and at least keep abreast of the times by developing new equipment for production in time of emergency? Our factories provide their labor with efficient equipment for purely business reasons. Our government, state and national, prescribes and enforces safety regulations. It would therefore seem that we must provide our soldiers who are drafted into the service in case of war with the safest and most efficient weapons possible to safeguard their lives and ours.

In order to visualize somewhat the amount of work required to develop a new type of ammunition, we will consider only one of the numerous components. For purposes of illustration, we will take the development of a fuze. Of this component the Westervelt Board states as follows: "The Board desires to emphasize the necessity for making the fuze for high explosive shell bore-safe. The French type superquick fuze is seriously defective in this regard. Destruction of cannon due to premature bursts during the past war has been enormous, due largely, in the opinion of the Board, to the use of this fuze." The loss of life due to this fuze was likewise large. This statement applies to a particular type of fuze known as the superquick, which was hastily developed during the war to meet needs not previously anticipated. We have this fuze in our reserve ammunition and it is the one required in largest quantities. The statement as to lack of safety applies, however, almost equally to all other types of fuzes now developed.

Bore-safe fuzes differ from the ordinary type in that the sensitive elements (primer and fulminate detonator) are entirely separated from the main explosive elements until the projectile leaves the bore and can therefore explode due to shock, without doing any damage. In the ordinary fuze, the safety device merely operates to keep the primer from being struck by the firing pin. These bore-safe fuzes, which will actually reduce the loss of life and loss of expensive



75-mm. New Shrapnel
1. Complefe Round Assembled. 2. Component Parts

artillery at critical times, are under development; that is, designs have been prepared and small lots have been tested with satisfactory results. Complete development of a fuze, however, requires not only manufacture on a considerable scale so as to be certain that the article can be produced in time of emergency by more or less inexperienced manufacturers, but the firing of sufficient rounds to indicate whether the fuze is safe and will fulfill service requirements.

The particular fuze which the Westervelt Board condemned as being notoriously unsafe gave on the average of one premature between 12,000 and 20,000 rounds. Other fuzes of the non-bore-safe type have considerably better records, some for the particular periods of one premature in about 240,000 rounds. With the bore-safe fuze we should, therefore, be able to reduce prematures to one in several hundred thousand rounds. The only way to determine that this action is being obtained is to fire that number of rounds, or several times that many, to obtain anything like an average. Actually, this would not be done entirely as a deveolpment program, so-called.

The procedure is usually to first prepare designs, and then picking out the most promising features to make up small lots and put through the necessary safety tests by dropping them, jumbling them in a manner which would give them the same shocks that they would be subjected to when transported over rough roads, and then firing tests in very small numbers. After this, lots of about 25 are made up for proving ground test. Several lots of this size are usually made up and if results are satisfactory a somewhat larger lot, say 200, is manufactured and fired, followed by a lot of say 1,000. The 1,000 would probably be fired in small groups with various calibers of cannon and under various range conditions. If the action under these conditions was satisfactory, we would next start small scale production of say about 5,000. Some of these might be fired

at the Proving Ground and others might be issued to the service, if it were decided that development had been carried out as far as practicable under proving ground conditions.

If the 5,000 proved satisfactory there might be a tentative adoption for service and the fuze manufactured in sufficient quantity for some or all organizations having target practice. This would be again followed, assuming satisfactory results, by larger scale production, if production of ammunition was in progress for target practice or for reserve. In other words, it would take a number of years and the firing of a large number of rounds, all under more or less careful observation, in order to really develop a fuze. Even then the question as to ability to produce under wartime production conditions would not be definitely answered. If, however, no difficulties had been encountered through the various stages and the specifications had been carefully prepared, based on the information obtained during the production, no great difficulties should be encountered later. There is no method of rushing a development to conclusion in a short time, and if we enter another war with undeveloped designs, we are certain to encounter the same difficulties in production that were encountered during the late war and will have the same delays, and exorbitant costs. The delays may be more serious due to not having other sources of supply.

There are any number of development projects required, probably of equal importance with the fuze. All of these cannot be mentioned but the problem of the propellant appears worthy of consideration. Our present type of propellant is quite satisfactory when stored under careful conditions but is susceptible to the absorption of moisture if stored in leaky containers. Air-tight containers are almost impracticable with the handling under wartime conditions. The powder has another defect in that it gives off a considerable flash which reveals the gun positions in night firing. The requirements laid down by the Caliber Board for a satisfactory propellant are that it shall be smokeless, flashless and non-hygroscopic. The development of a flashless powder may be considered as important a step as was the development of a smokeless powder to replace the old black powder. Not to develop this flashless powder would leave us at a decided disadvantage in case of another war. The condition would be quite the same as that prevailing during the Spanish-American War when our troops were armed largely with old type rifles shooting black powder ammunition instead of smokeless powder with which other countries were generally provided at that time.

The question has been asked as to whether the ammunition development program will not be completed in the course of the next few years, so that designs and specifications could be placed on file and further development work stop. Development can never be completed unless all progress stops. The projectiles, fuzes, propellants, etc., developed in 1922 will be somewhat inferior to what might be done in 1923, and further developments from year to year will soon make it necessary to get new types. It is of course necessary to maintain some stability of design and types developed in 1922 might not actually be superseded for 10 or more years but the ground for improved types should be laid during that time by recording the defects of existing types and devising methods for overcoming them. When we understand the amount of work necessary to develop a single component of a round of ammunition and then consider that about a dozen different types of fuzes are needed to meet the tactical requirements, several different types of projectiles for each of the many calibers, propellants, high explosives, primers, etc., to meet various requirements, and that we have parallel problems in drop bombs of various sizes and types and the fuzes adapted to their uses; grenades, pyrotechnics, etc., to meet the various requirements, it will be realized that we are not likely to ever reach the point where we can say the development of ammunition is up to date.

Are further radical improvements to be expected? There is no reason to believe that the practical limit of range of projectiles has been approached. The best 75 mm. shell has a range of not over one-fourth of the theoretical range in vacuo. We have had smokeless, then flashless powder, Why not soundless powder to offset the sound ranging? We have had improvements in fuzes. The clock-work fuze is expected to give extremely accurate timing, but why not a fuze that can be set directly for a distance or to burst a projectile at a certain height independent of range or time? This would bring back the shrapnel. These problems are not impossible of solution. We have not yet reached the point where we can say there is no further invention open to be made on ammunition.

NEW YORK POST—ARMY ORDNANCE ASSOCIATION

Trip to Raritan Arsenal, June 9, 1922

The New York Post, Army Ordnance Association, and its guests, will visit Raritan Arsenal, Friday, June 9, 1922, by invitation of its Commanding Officer. This arsenal is the greatest distribution point for Ordnance matériel in the country, covers an area of 2,200 acres and has over $300,000,000 worth of materiel on hand. The trip will be of especial interest to all Ordnance Reserve officers, as showing them the latest practice in their respective duties. The main party will make the trip from the Battery at New York, on government steamer to Raritan Arsenal, but some may desire to go by private automobile or railroad. The party, upon arrival at Raritan Arsenal, will be divided into small groups, each in charge of an officer guide, in order that all may receive the maximum information possible, and the following features will be given especial attention:

I. Ordnance Specialists' School.

This extensive school is maintained to train Ordnance personnel for the operation, maintenance and repair of all kinds of ordnance matériel and should be of especial interest to Reserve officers assigned to Ordnance Maintenance Companies.

II. Repair Shops.

Tractor, truck, small arms and machine gun.

III. Ordnance Provision System and Method of Group Issue.

Of especial interest to Supply and Depot officers and officers assigned to ammunition companies.

TRANSPORTATION AND LUNCHEON ARRANGEMENTS.
(The time shown is Daylight Saving Time.)

1. By government Steamer *Ordnance*. (No charge.)
   Leave Pier A, Battery, New York City, 8:45 A. M. Arrive Raritan Arsenal about 11:30 A. M.
   Leave Raritan Arsenal, 4 P. M. Arrive Pier A, Battery, New York City, about 7 P. M.
2. By Pennsylvania Railroad.
   Leave Pennsylvania Terminal, New York City, 9:20 A. M. Arrive Metuchen, N. J., 10:14 A. M.
   Leave Metuchen, N. J., 4:32 P. M. Arrive Pennsylvania Terminal, New York City, 5:23 P. M.
   Government automobiles will meet trains.
3. By private automobile.
   Choice of two routes: 1. Ferry to Staten Island; across Staten Island to Tottenville, ferry to Perth Amboy; thence direct road to Metuchen. 2. Ferry across Hudson River; thence through Newark, Elizabeth and Rahway to Metuchen. Total time required, about 2 hours.

Luncheon will be served at the Arsenal, costing 50 cents. Members are requested to notify Captain H. S. Wilkins, Corps Ordnance Office, Governors Island, N. Y., if they wish to accept the invitation to visit Raritan Arsenal, and if they wish him to reserve luncheon for them at the Arsenal.

Anti-Aircraft Machine Gunnery

Part II. Anti-Aircraft Sights and Range-Finding

By

S. G. GREEN

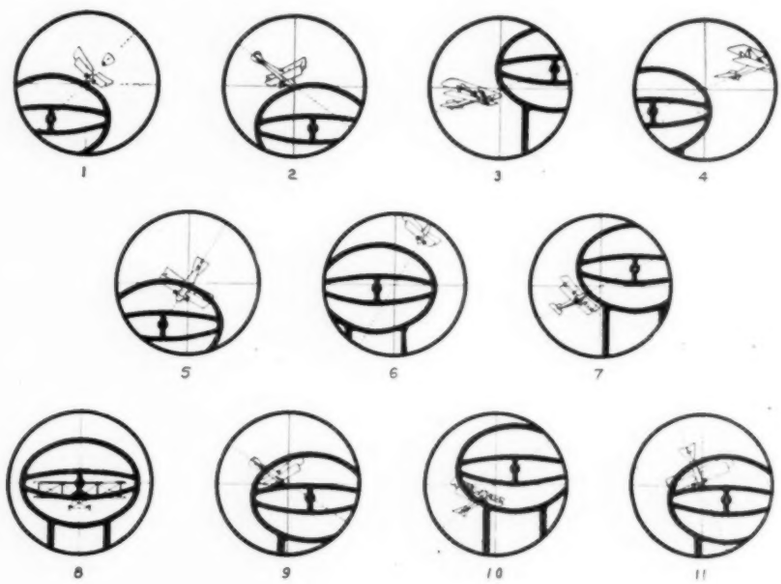
Member A. O. A.

Correct and Incorrect Aiming with the Front Area Sight, Anti-aircraft

Fig. 1. Outer ring in use (altitude 500 to 3,000 feet). CORRECT. The airplane is flying toward the ring center, the nose of the airplane is touching the outer edge of the ring being used, and the point where the nose of the airplane touches the outer edge of the ring is centered in the back-sight aperture.

Fig. 2. Outer ring in use (altitude 500 to 3,000 feet). INCORRECT. The airplane, while touching the outer edge of the ring being used, is *not* flying toward the ring center. The bullets will pass below the target.

Fig. 7. Outer ring in use (altitude 500 to 3,000 feet). INCORRECT. The point where the nose of the airplane touches the outer edge of the ring used is *not centered* in the back aperture. Even though the airplane *is* flying toward the ring center and touching the ring edge properly, the point of nose contact being off center will cause the bullets to pass in front of the airplane.



The Circle Inclosing Airplane and Section of Front Sight Represents the Rear Sight Aperture

Fig. 3. Outer ring in use (altitude 500 to 3,000 feet). INCORRECT. The nose of the airplane is *not* touching the outer edge of the ring, although it *is* flying toward the ring center. If fire were opened on this sighting the bullets would pass in front of the target.

Fig. 4. Outer ring in use (altitude 500 to 3,000 feet). INCORRECT. The airplane is flying *away* from, instead of toward, the ring center. Bullets would pass a long way behind the target.

Fig. 5. Outer ring in use (altitude 500 to 3,000 feet). INCORRECT. The nose of the airplane is *not* touching the outer edge of the ring being used; but has passed inside that ring too close to the ring center. On this sighting fire would be opened too late and the bullets would pass behind any vital part of the airplane.

Fig. 6. Either outer or inner ring in use. INCORRECT. The airplane is *not flying toward ring center,* the nose is *not touching the outer edge of ring being used,* and the point where the nose of airplane would touch either ring is not centered in the back sight. The bullets would pass in front and to the left of the airplane.

Fig. 8. Center aperture in use. CORRECT. The airplane is diving toward the gun. Aim is taken by aligning the ring center aperture, centered in the back sight aperture, upon the middle of the upper part of the plane. The bullets will then hit the vital parts of the airplane.

Fig. 9. Inner ring in use (up to 500 feet). CORRECT. The airplane is flying toward the center of the ring, the nose of the airplane is touching the outer edge of the ring being used, and the point of contact between the nose of the airplane and the outer edge of the ring used is centered in the back sight aperture.

Fig. 10. Inner ring in use (up to 500 feet). INCORRECT. The nose of the airplane is *not touching* the outer edge of the ring being used. The bullets would pass in front of the target.

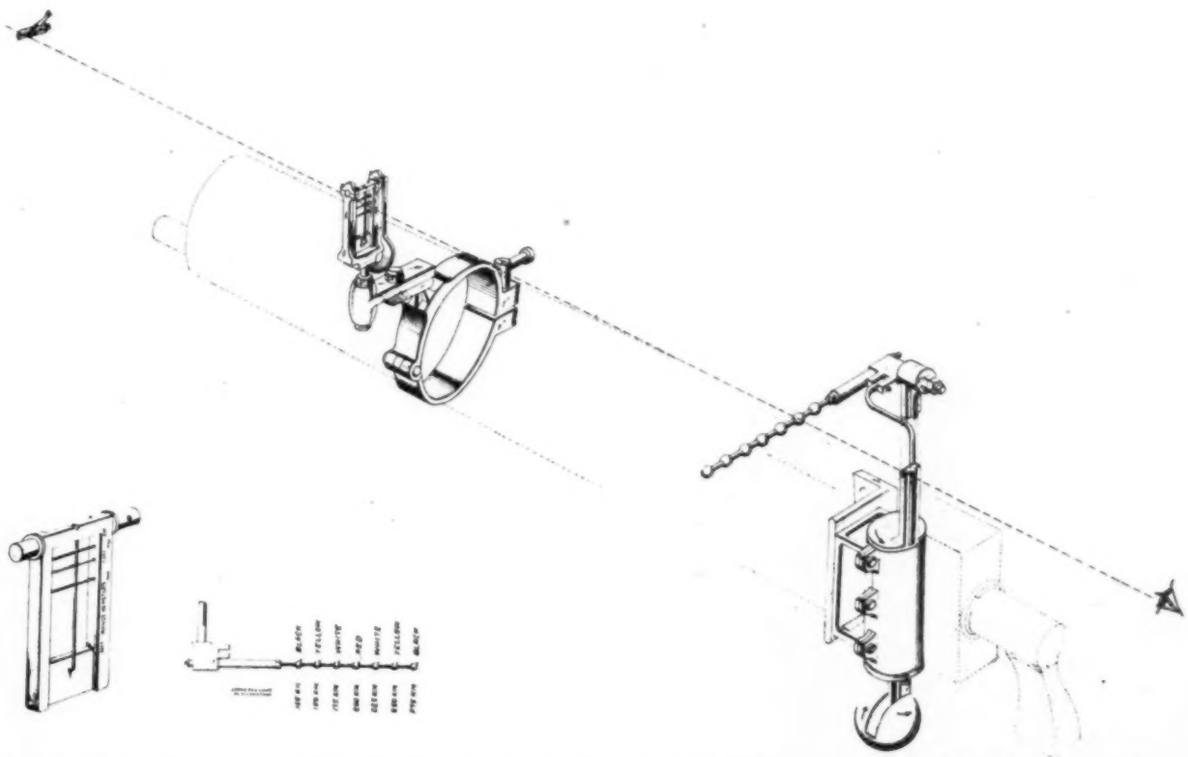
Fig. 11. Inner ring in use (up to 500 feet). INCORRECT. The airplane is *not flying toward* the ring center. The bullets would pass to the right of the airplane.

Anti-aircraft Sights

The anti-aireraft sight development for small arms during the World War was confined principally to two types: the "front area" sight, a development from the trench sight, and the "rear area" sight, a development from the (Peycru) long range anti-aircraft sight. The trench sight as provided during the war consisted of an elliptical shaped front sight, which was mounted on a bracket secured to the jacket of the barrel of the weapon. The sight was held in the vertical position by a lock pin, inserted after the sight was raised. The pin was removed when the sight was lowered and reinserted to hold the sight in the down position. The oval consisted of an inner ellipse and an outer ellipse to compensate for two ranges and speeds of planes. The ovals were made up from stampings, the width of which (as shown in the cut) was such as to practically obscure the target from the gunner when in firing position.

The "front area" (trench) sight was completely redesigned and the width of the ovals was reduced to such an extent as to practically eliminate the obstruction of the target to the gunner. The method of mounting was redesigned and the leaf held in the down or vertical position by a cam plunger. In this way, the sight could be readily raised and lowered at will with practically no loss of time for getting into action. The rear sight of the wartime design consisted of an auxiliary frame carried on the regular rear sight on which was drilled a hole approximately .3-inch in diameter. This auxiliary frame in most cases was cumbersome and rendered the standard rear sight practically unserviceable. With the present tactical employment of anti-aireraft guns this would be a serious handicap, in that all guns should be readily converted into anti-aireraft or into infantry guns or vice versa at very short notice. To accomplish this result, the regular rear sight furnished with the standard Browning machine gun was modified accordingly.

Improved Post Mount, Anti-Aircraft, with Browning Automatic Rifle, Trench Sight and 40-Round Magazine



The Anti-aircraft Sight, Peycru (Rear Area Antl-aircraft Sight). Shown as Mounted on a Browniñg Machine Gun, Model of 1917. The Gunner is Sighting at an Aircraft Across the 150-kilometer Bead (Inner Yellow) of the Rear Sight and the 1.000-meter Range Cross Wire of the Front Sight. An Enlarged View of Front Sight Window Frame and Rear Sight Beaded Sighting Bar is Shown in the Lower Left Corner of the Plate.

Range Finding

The range finders extensively employed for small arms anti-aircraft use consist of the stadia, the field type coincidence range finder, and tracer ammunition. The coincidence range finder is the regular range finder used by the light artillery for general field work. The stadia is a very simple device for gaining a quick estimate of the distance of an aircraft.

Theory of Use of the Stadia

Assume the point E as the eye, and points A—B as two opposite points on corresponding lugs or notches in V opening of stadia, and D—G as the length or width of an aircraft. The line E—C is at right angle to the line A—B and is the fixed distance from the eye to the stadia, representing the string when held taut.

Then, since A B and D G are known and fixed, and

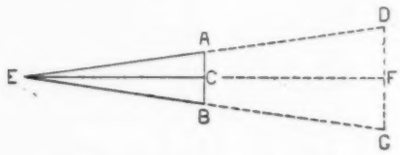


Diagram Illustrating Theory of the Stadia

the angle A E C is the same as the angle D E F and fixed, and the length of line E C known and fixed, the length of the range line E F is fixed and may be calculated, as has been done for the various sighting points marked on the stadia. The range graduations on the stadia (in meters) are based on the following assumed dimensions of aircraft viewed:

Combat type: Side view, 7 meters; end view, 9 meters.
Bombing type: Side view, 8 meters; end view, 12½ meters.

Directions for Use of Stadia

(a) Identify the aircraft viewed, type and dimensions.

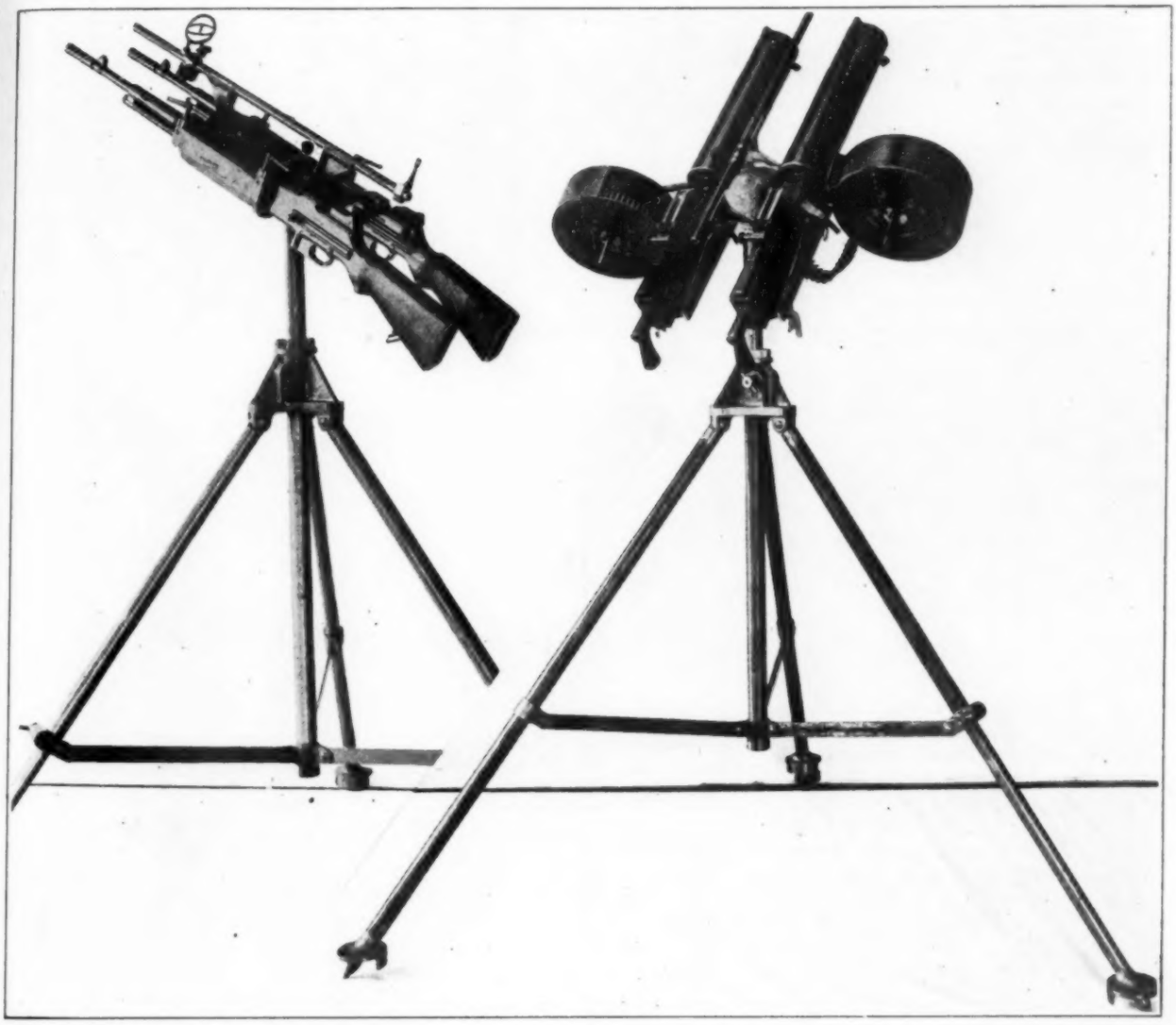
(b) Decide which end V opening of the stadia suits the type of the aircraft, "combat" or "bombing."

The Stadia Range Indicator in Use

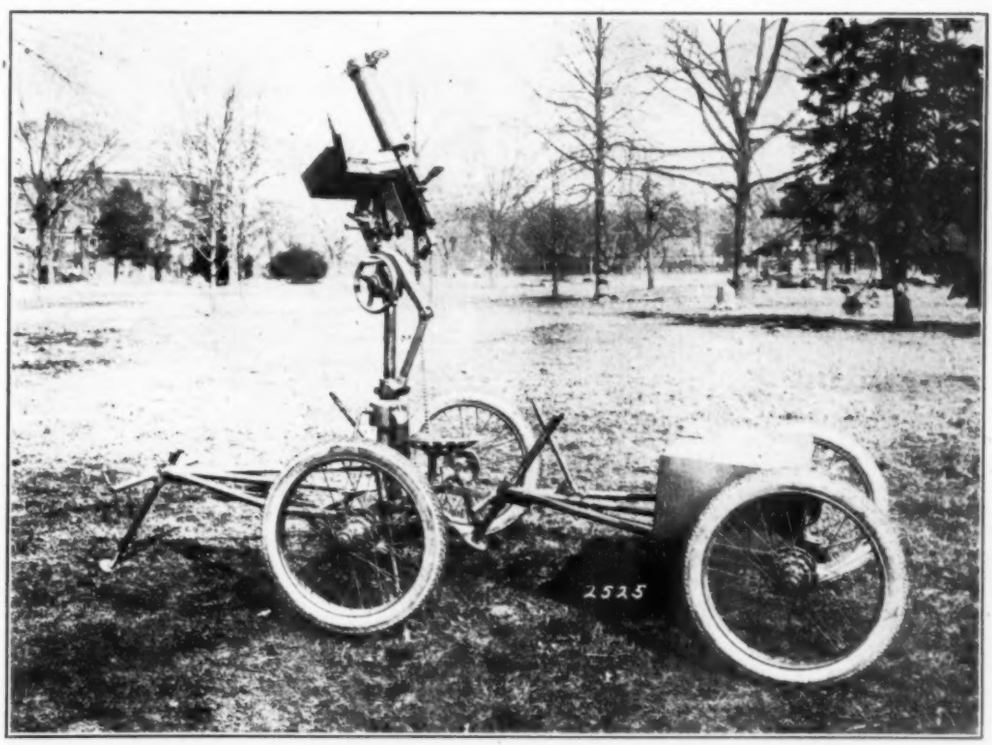
(c) Grasp the stadia by its lower part in one hand with proper opening uppermost and graduated side faced Loosen the string with the other hand and press the beaded tip of it against the chin. Extend the hand holding the stadia until the spring is taut. Close one eye. Hold stadia between the eye and the aircraft and move it about until the aircraft appears as bridging across the V opening with its outermost edges just touching the opposite sides of same. If the aircraft is seen in profile it should appear as bridging across corresponding lugs, nose touching one and tail the other; if seen end-on it should be framed in a notch or recess between lugs, wing tips touching the opposite walls of the V. Note the range indicated by the range scale at the point where the correct appearance of the aircraft occurs, and instantly call range to gunner.

Stadia, Peycru, complete

As issued to the service, the stadia consists of a metal plate having "V" shaped openings of a determined size through which the aircraft is viewed while the plate is held at right angles and a fixed distance from the eye. The fixed distance from the eye is accomplished by attaching a string approximately 22 inches long at the center point of the stadia and one holding the other end of the string against the face of the observer similar to the method of using the Battery Commander's Rule. The design of the stadia is based upon the theory that a given opening at a point of the "V" when held at a fixed distance from the eye will allow the observer to see an object of a fixed width at a given range. The range and width of the object observed will be in proportion to the distance the stadia is



Upper—Anti-aircraft Mount, Model of 1921. Left—Two Browning Automatic Rifles Mounted. Right—Two Browning Machine Guns Mounted.



At the Right—Anti-aircraft machine Gun Mount on Cygnet Trailer with Ammunition Trailer, Browning Machine Gun, Browning and Vickers Adapter, Browning Ammunition Box with Cartridge Belt Guide. Trench Sight.

held from the observer, and the opening at this point of the "V." The targets of the anti-aircraft gunner can be classed as scout planes, combat planes, bombing planes, dirigible, aircraft, etc. Since the width of the side elevation and end elevation of these targets are accurately known, they can be viewed at a given point of the "V" of the stadia and the range estimated accordingly. This simplifies the stadia in that the points of the "V" that cover the fixed width at a known range can be graduated in terms of range. The cuts show the general design of the stadia and its application. With the stadia as shown in cut, the observer has only to determine the type of aircraft and the point on the "V" of the stadia which most nearly takes in the width of the target. The range graduation nearest this point is the estimated range for use of the anti-aircraft gunner. The design of the stadia varies as to method of holding and details of structure; however, the principles of operation are the same.

It is contemplated providing an adjustable stadia to accomplish the width variation of the target aircraft in the air that will probably be the targets of the aircraft gun of the future. In this way the sight can be readily set, once the target has been identified and the range read off direct. When considering the speed of travel of the aircraft and the time interval for actually delivering effective fire upon the target aircraft, it is not of great importance that the range should be estimated closer than within 100 to 250 yards, as the sights are designed to compensate for this variation in ranging. Small arms anti-aircraft gunners also gain valuable data from other units which obtain this information from more elaborate devices. Both sighting and range finding for small arms anti-aircraft gunners are materially aided by the use of tracer and incendiary ammunition, which assists in locating as well as estimating the ranges of the target.

The ranging for anti-aircraft gunnery for small arms is greatly assisted by the use of tracer tmmunition, as direct observation can be made of the trajectory, which is approximately the same as that of armor piercing, incendiary and service ammunition.

Anti-aircraft Machine Gun Tripod, Model of 1918, as Used with Browning Machine Gun, with Shoulder Stock, Browning and Vickers Adapter, Trench Sight, Browning Ammunition Box and Cartridge Belt Guide.

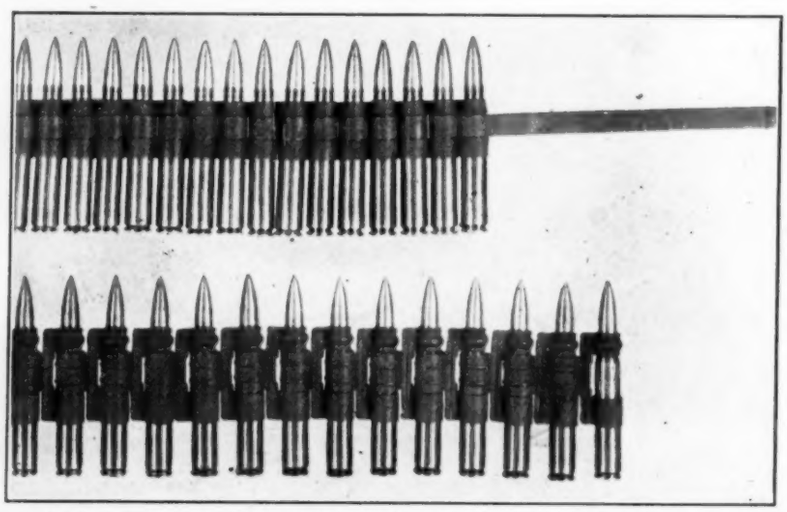
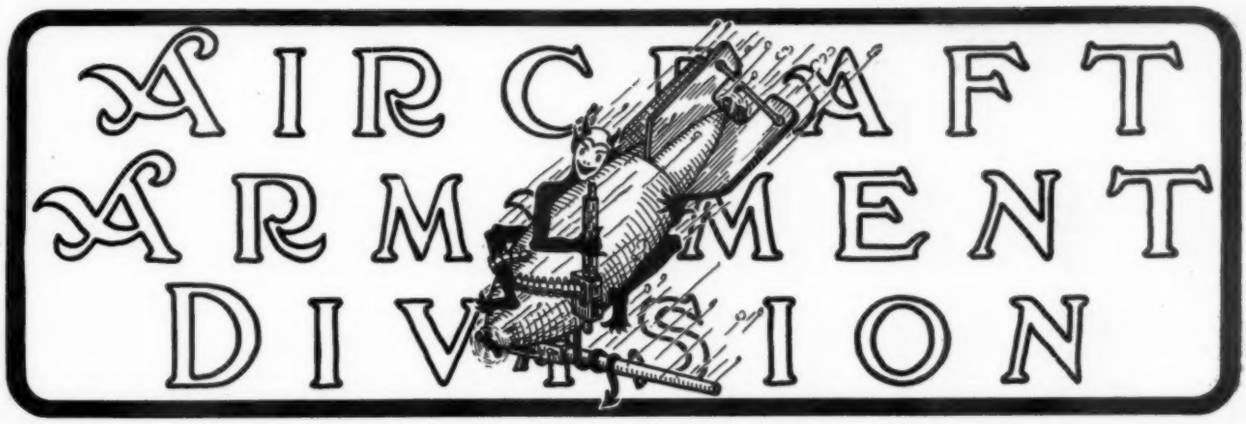


Fig. 18—Sections of Disintegrating Belts of Metallic Links Used by United States Army

(NOTE.—On page 142 of the November-December number of ARMY ORDNANCE, a footnote under Fig. 3, ascribed the invention of the training device for anti-aircraft machine gunners, illustrated in that figure, to Captain S. G. Green, author of the article entitled "Anti-Aircraft Machine Gunnery," of which Part II is printed above. While Captain Green is the inventor of many devices used in connection with anti-aircraft machine gunnery and has, as a matter of fact, been responsible for several improvements in the device in question, the actual inventor was Mr. Elwin K. Hill, of Cleveland, Ohio, a member of this Association. We are very glad to make this correction of an unintentional and regrettable error. —ED.)



History of the Aircraft Armament Division

On March 29, 1922, the Aircraft Armament Division ceased to exist as a separate division under the Chief of Manufacture in the Office of the Chief of Ordnance. The work of the division had progressed to the point where it could be carried on satisfactorily without the necessity of giving it the special attention of a separate organization and with the reduction in personnel requiring a concentration of forces in the Ordnance Office the Aircraft Armament Division was abolished. The Bomb Section of the division, under Captain C. H. M. Roberts, was transferred to the Ammunition Division and the Machine Gun and Cannon Section, under Captain T. M. Jervey, was combined with the Small Arms Division into the Infantry and Aircraft Armament Division.

The record of the Aircraft Armament Division is an enviable one. The first organization bearing the title of Aircraft Armament Division was that section of the Ordnance Department in France which handled all work pertaining to Aircraft Armament in the A. E. F. This organization started its work on November 1, 1917, when Captain Harry J. Malony with four other officers reported for duty in France and were assigned the difficult task of designing, procuring, installing and maintaining aircraft armament for all aircraft in the A. E. F. This small force of five officers grew to an organization of 240 officers and 1900 enlisted men. Special acceptance and testing fields and fields where aircraft armament was installed in aircraft were developed and operated by the Air Service in co-operation with this division. The actual work of the division was extended into the Air Service Squadrons where an officer and a group of enlisted men maintained the armament in service.

As an example of some of the work performed by the division, it is of interest to note that Captain Jervey was a member of the Aircraft Armament Division in France and attached as armament officer of the 91st Observation Squadron. While on this duty, and although not required to do so, he acted as observer on numerous flights and participated in several air battles. He is officially credited with shooting down three German airplanes and was awarded a Distinguished Service Cross for completing a photographic mission in the face of great odds and an attack by fourteen German airplanes.

The work of the Aircraft Armament Section in France was so satisfactorily performed that a Distinguished Service Medal was conferred on Colonel Malony, its chief. The following letter testifies as to the manner in which the work of the section was performed:

AMERICAN EXPEDITIONARY FORCES
HEADQUARTERS U. S. AIR SERVICE
A. P. O. 702

November 27, 1918.

From: Assistant Chief of Air Service, A. P. O. 702, American E. F.
To: Chief Ordnance Officer, E. F., A. P. O. 717.
Subject: Aircraft Armament Section.

1. I desire to take this opportunity of expressing to you my appreciation of the able and efficient work of the Aircraft Armament Section, Ordnance Department. This Section has been associated with the Air Service for over a year, and during that period their work at all times has been exceedingly satisfactory to myself and to the Air Service. It is felt that without the energy, loyalty and devotion to duty shown by this section it would have been impossible to put combat planes on the front.

2. They have been confronted with many difficult situations and have met and overcome their difficulties in a highly commendable manner. I believe it is the general impression throughout the Air Service that the Ordnance Department has rendered us valuable and efficient service.

3. From a supply standpoint there has never been a single delay in equipment of planes or mobilization of squadrons due to a lack of airplane ordnance nor to a lack of competent men to install it for us. This is also true of military operations. The experience gained by this section has been of great value to the service in general and has provided us with a large amount of valuable information which it is felt will not be lost to the service and which is exceedingly difficult to obtain from other services. I believe that our Aircraft Armament Section has shown by far greater ability than the corresponding sections of the allied services. At any rate we have covered in an armament way in one year the ground covered by the allied forces during their whole war experience, and in many items of armament I believe that we have surpassed them in efficiency. This is due to the efforts of the Aircraft Armament Section alone, and I desire to congratulate you upon the efficiency with which this work was undertaken and carried out.

(Signed) H. DUNWOODY,
Colonel, Air Service, U. S. A.,
Assistant Chief of Air Service.

During the war there was no single organization charged exclusively with the development of aircraft armament in the United States. The Ordnance Department developed part of the material and the Air Service the remainder. The installation of the material was charged to the Air Service. The material handled by the Ordnance Department was first divided between two sections; bombs, bomb racks and bomb sights being handled by a sub-section in the Trench Warfare Section of the Gun Division, and machine guns and cannon by a subsection of the Small Arms Section of the Carriage Division. The designations of these sections changed from time to time as changes were effected in the Ordnance Office. During the first sixteen months of the war Lieutenant Colonel E. J. W. Ragsdale of the Trench Warfare organization was in general charge of bombs, bomb racks and bomb sights and Colonel Earl McFarland of the Small Arms organization was in general charge of aircraft machine guns and cannon.

In August, 1918, Aircraft Armament engineering activities in the Ordnance Office were combined into an Aircraft Armament Section of the Engineering Division under Colonel McFarland. This section formed the nucleus of the Aircraft Armament Division which was organized later. The concentration of aircraft armament activities was effected by transferring the Bomb sub-section, under Major John H. Barr, from the Trench Warfare Section and the Machine Gun and Cannon sub-sections of the Small Arms Section, under Major Herbert O'Leary, to the newly formed section. Actually the Aircraft Armament and Small Arms Sections of the Engineering Division combined under Colonel McFarland as Chief.

In January, 1919, all engineering, production and inspection activities pertaining to aircraft armament were combined in an Aircraft Armament Division under a Chief of Manufacture. Colonel McFarland was the first chief of the division and remained as its chief and also as chief of the Small Arms Division until April, when he became Special Assistant to the Chief of Ordnance in charge of Equipment, Automatic Arms, Rifles, Pistols, etc.

A Distinguished Service Medal was conferred upon Colonel McFarland for the services performed by him during the war, no small part of which pertained to the design, development and production of machine guns for aircraft use.

Lieutenant Colonel Herbert O'Leary became the next chief of the division. The organization was still combined with the Small Arms Division under one chief.

On August 15, 1919, the Aircraft Armament Division was ordered to operate as a separate division and to be no longer affiliated with the Small Arms Division. Lieutenant Colonel Harry J. Malony, who had returned from France, was designated chief of the division. The action taken was for the purpose of concentrating the effort of a single organization on aircraft armament. The war had demonstrated the military importance of aircraft and the development of aircraft

and its armament required that particular effort be made by this country in this development in order to keep in step with the progress made abroad. In line with this requirement, realizing the importance of aircraft armament and desiring to afford every facility for its efficient and prompt development, the Chief of Ordnance placed the work with this independent division in the Ordnance Office.

Lieutenant Colonel Malony continued as Chief of the Division until February, 1920, when he was relieved to take command of the Savanna Proving Ground. Lieutenant Colonel William A. Borden, who since October, 1918, had been in charge of the Bomb Section, was appointed Chief of the Division and continued as such until the Division was abolished.

An important section of the Division was created in October, 1918, when the Dayton Branch, under Lieutenant Colonel Harry D. Wood, was organized. Individuals and small units of the Division had from time to time been stationed at Dayton, Ohio, but until that date no official branch had been permanently located there. The Branch was created for the purpose of coordinating the work on aircraft armament by the Ordnance Department with the work on aircraft undertaken by the Engineering Division of the Air Service. This Branch, under Lieutenant Colonel Weed and later under Lieutenant Colonel W. L. Clay, did splendid work in the development of bomb racks and aircraft machine guns. The designs developed for the bomb racks are fundamentally basic designs which are, and no doubt will be, used in all rack designs for years to come. The standardization of dimensions for aircraft machine guns and their mountings accomplished by this Branch is of great importance in facilitating the carrying on of development work on aircraft weapons. With the transfer of control over bomb racks, bomb sights and other miscellaneous equipment to the Air Service, the work of the Branch was reduced to the point where its retention was not warranted and in July, 1921, it was abolished. The Machine Gun Section of the Branch under Captain Walter T. Gorton was transferred to Springfield Armory to carry on experimental and development work on aircraft machine guns.

The war work of the sections which made up the Aircraft Armament Division and the Division itself is recorded in several histories of the war activities of the Ordnance Department. It is impossible to record here all that was accomplished. The material was entirely new and almost all of it had to be developed after our entrance in the war. 39,200 Lewis Aircraft Machine Guns; 38,000 Marlin Aircraft Machine Guns, and 3,714 Vickers Aircraft Machine Guns were produced by the end of 1918, of which 1393 Lewis, 1220 Marlin and 1320 Vickers guns were used at the front. 21,000 Fragmentation Bombs of one type were produced by November 30, 1918, and another type was being produced at the rate of 500 a day. 220,000 50-pound Demolition Bombs were completed by the Fall of 1918, and one concern was producing these at the rate of 1200 bombs a day. 153,000 100-pound Demolition Bombs had been manufactured by November, 1918, and 7,000 of these could be produced daily by that time. On orders for 300- and 600-pound Demolition Bombs, 39,400 had been completed by the day the Armistice was signed. It must be stated that although this large production in bombs was obtained, very few had been actually loaded and shipped to France when hostilities ceased, but quantity loading was in sight and with the erection of a loading plant for bombs, which was in progress, large numbers of loaded bombs would have shortly been on their way to the A. E. F. Belt links for the machine guns, bomb sights and bomb racks and numereous other items of armament were in quantity production before November, 1918, and many of these were used at the front.

With the termination of hostilities and the evident necessity of continuing the development of new items of aircraft armament, it became apparent that a definite program of development should be drawn up to cover the items of armament which the experiences of the war indicated were required. A Bomb Board and an Aircraft Machine Gun and Cannon Board, composed of Air Service and Ordnance officers, were convened for this purpose and the recommendations in the reports of these boards have since been used as the programs of development of the Aircraft Armament Division.

In following out the programs outlined by these boards, the Division has developed numerous new items of armament and has improved on many of the items already in existence. The .30 caliber Browning Aircraft Machine Gun has been improved and a new model will be shortly available for service test. A .30 caliber aircraft machine gun which can feed from either the right or left hand side as desired has been developed, and one gun has been quite satisfactorily tested. A .50 caliber aircraft machine gun has been developed by the Colt Company in collaboration with the division and several of these are under manufacture for service test. A right and left hand feed .50 caliber aircraft gun has been also developed by the Colt Company and one gun is ready for test. Rounds counters and indicators, magazines, belt links and other accessories for aircraft guns are in process of development with indications that satisfactory equipment will soon be available. Bombs of all types are under development and basic designs of fragmentation and demolition bombs up to and including 2,000 pounds in weight are available. A 4,000-pound Demolition Bomb, the largest bomb produced in the world, was developed by the Division and the first one was successfully tested during the summer of 1921. Great strides have been made in producing bomb fuses, and advanced designs of these are under development for all bombs and will shortly be available for issue. The subject of bomb ballistics has received particular attention and numerous tests have been run in the wind tunnels at the Bureau of Standards and many bombs have been dropped in tests at Aberdeen Proving Ground to determine the flight characteristics of bombs.

There have been developed and installed at Aberdeen Proving Ground facilities for testing bombs which are believed to be as complete as any in the world. The development of this equipment and the supervision of its installation is largely due to the efforts of personnel of the Aircraft Armament Division.

When the Air Service called upon the Ordnance Department for various types of bombs, several of which were larger in size than any then available, and asked for these in quantity for use in the bombing tests to be conducted against the ex-German naval vessels in the summer of 1921, the Aircraft Armament Division developed and supervised the production of these bombs, issuing all bombs requisitioned in adequate time for the tests. The ex-German Destroyer G-103 was sunk by Army 300-pound Demolition Bombs, the ex-German Cruiser *Frankfort* was sunk by Army 600-pound Demolition Bombs and the ex-German Battleship *Ostfriesland* was sunk by Army 2,000-pound Demolition Bombs. The satisfactory performance of the bombs elicited the following letter from the Executive Chief of Staff to the Chief of Ordnance:

July 22, 1921.

From: The Executive Assistant to the Chief of Staff.
To: The Chief of Ordnance.
Subject: Recent Bombing Demonstrations.

The Secretary of War directs me to express to you his satisfaction with the important part played by the Ordnance Department in the recent bombing tests which he witnessed this week near Hampton Roads. He realizes that the construction of fuses for a 2,000-pound projectile is something new to our practice, and noted with great satisfaction that the bombs used by the Army seemed to be entirely reliable. He is very much pleased with the result and desires that you and your subordinates know it.

(Signed) J. G. HARBORD,
Major General, General Staff.

The Aircraft Armament Division was commanded by the Chief of Ordnance for its work in developing and making available the bombs for the tests, as follows

WAR DEPARTMENT
OFFICE OF THE CHIEF OF ORDNANCE
WASHINGTON

August 3, 1921.

From: The Chief of Ordnance.
To: The Aircraft Armament Division.
Subject: Commendation for Excellent Work in Connection with Development of Bombs.

1. Upon the successful completion of the bombing maneuvers recently held by the Air Service at Langley Field, I desire to extend to the personnel of the Aircraft Armament Division the thanks of the Ordnance Department for the efficient manner in which they have discharged their duties.

2. Without the personal interest and loyal cooperation of each member of the Division, the success of the maneuvers from an Ordnance viewpoint would have been difficult of achievement. In the rush of getting out designs of new material and in the vast amount of clerical work involved, you exhibited a most gratifying personal interest in the success of the project and frequently worked overtime in order to complete work of special importance.

3. I wish to personally thank you and to assure you of my sincere appreciation of your efforts.

(Signed) C. C. WILLIAMS,
Major General, Chief of Ordnance, U. S. A.

The effort of the Division since the signing of the Armistice has been to develop and make available drawings, specifications and handbooks of aircraft armament material so that in case of an emergency the material could be placed in quantity manufacture without delay. In addition, the manufacture of certain material has been initiated as funds became

Continued on Page 382

Artillery Division Notes

Transmission for Divisional Tractor, Model of 1920.—The transmission designed for the Divisional Tractor, Model of 1920, presents some interesting features of construction and operation. It provides four forward and two reverse speeds by shifting only three gears and has the added feature of allowing the opposite tracks to be driven positively at different speeds. This gives an advantage in steering over the conventional method of merely disengaging the power from one track or stopping it by means of a brake, although steering in the conventional manner is still possible with this new transmission.

For simplicity in describing its construction and operation only two diagrammatic views of the gearing are given herewith, Fig. I being a plan and Fig. II an end view. Referring to Fig. I, power enters the transmission from the motor by shaft 1, its proper relation to the two power outlet shafts 2 and 3 being shown in the end view. Shaft 1 is splined and carries two sliding sleeves, one of which carries the gears 8 and 9, the other carrying gear 10. In order to show the proper meshing of gears 8, 9 and 10, shaft 1 must be shown out of true position in Fig. I. The shifting of gears 8, 9 and 10 is done by a hand lever through shifting forks in the conventional way, the usual interlock mechanism preventing the engaging of more than one shifting gear at a time.

Shaft 3 carries a loosely mounted sleeve to which are attached the three gears 11, 12 and 13 and the driving elements of the clutch 4. Shaft 3 also carries another loosely mounted sleeve to which are attached gear 14 and the driving elements of the clutch 7. The driven elements of clutches 4 and 7 are secured to shaft 3.

Shaft 2 carries two loosely mounted sleeves, one of which carries gear 17 and the driving elements of the clutch 6, the other sleeve carrying gears 15 and 16 and the driving elements of the clutch 5. The driven elements of both clutches 5 and 6 are secured to the shaft 2.

Gears 14 and 17 are the same size, gears 11 and 15 are the same size and gears 13 and 16 are the same size. From the diagram it is apparent that the driving elements of all clutches are in motion if any one is, clutches 4 and 5 rotating at the same speed and clutches 6 and 7 rotating at the same speed which is higher than that of the other clutches due to the ratio of gears 11 and 15 to 14 and 17. It will be noted, however, that the direction of rotation of clutches 4 and 7 is opposite to that of 5 and 6, but through the arrangement of the bevel gears 18 and 19 the drive sprockets 20 are driven in the same direction.

Clutches 4 and 7 are operated by one hand lever at the left of the driver and clutches 5 and 6 by one hand lever at the right of the driver. The operating mechanism is so arranged that with the levers vertical both clutches are disengaged, and the engagement of either clutch on a shaft is accomplished without affecting the other one. Pulling the right hand lever back engages clutch 5, while pushing it forward engages clutch 6. Similarly, pulling the left hand lever back engages clutch 4, while pushing it forward engages clutch 7.

The various speeds are obtained as follows:

(a) Low or First Speed: Gear 8 is slid into mesh with gear 11 by means of the gear shift lever mentioned above, and clutches 4 and 5 are engaged by pulling back both clutch levers. The drive coming in by shaft 1 is then transmitted through gear 8 to gear 11, then through the sleeve to gear 13 and the driving elements of clutch 4. Gear 13 being the same size as gear 16 the sleeve carrying the driving elements of clutch 5 is driven at same rate as clutch 4. Clutches 4 and 5 being engaged the drive is transmitted to shafts 3 and 2 and thence to the sprockets.

(b) Second Speed: With gear 8 still in mesh with gear 11, both clutch hand levers are pushed forward disengaging clutches 4 and 5 and engaging clutches 6 and 7. The drive is now transmitted from shaft 1 through gear 8 to gear 11 and through gear 11 to gear 17 and the driving elements of clutch 6, and also through gear 13 to gear 16, through the sleeve to gear 15 and thence to gear 14 and the driving elements of clutch 7. Clutches 6 and 7 being engaged, the drive is transmitted to shafts 3 and 2 and thence to the sprockets. It can be seen from the diagram that the speed of shafts 3 and 2 is increased over that of low speed due to the step up from gears 11 and 15 to gears 17 and 14.

(c) Third Speed: Gear 8 is slid out of mesh with gear 11 and gear 9 is slid into mesh with gear 12. Both clutch hand levers are pulled back engaging clutches 4 and 5. The path of the drive is now similar to that for first speed except that, owing to the higher reduction from gear 9 to gear 12, the speed of shafts 2 and 3 is correspondingly greater.

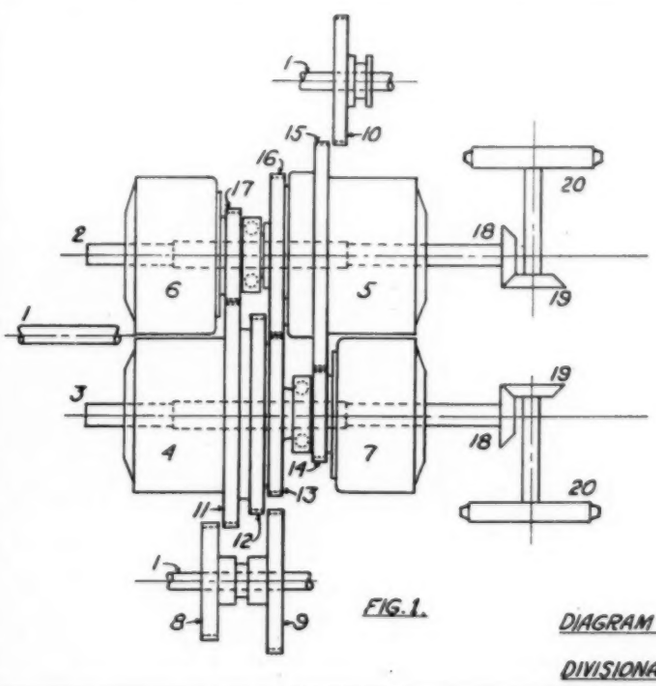


FIG. 1.

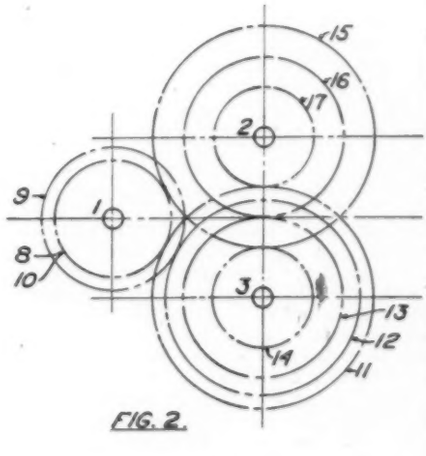


FIG. 2.

DIAGRAM OF TRANSMISSION GEARING FOR DIVISIONAL TRACTOR, MODEL OF 1920.

(d) Fourth Speed: With gear 9 still in mesh with gear 12, both clutch hand levers are pushed forward disengaging clutches 4 and 5 and engaging clutches 6 and 7. This produces an increase in the speed of shafts 2 and 3 proportionate to the increase of 2d speed over 1st, the path of the drive being similar to that of 2d speed except for the difference in the drive from shaft 1.

(e) Low Reverse. By means of the gear shift hand lever, gear 10 is slid into mesh with gear 15, and both clutch hand levers are pulled back, engaging clutches 4 and 5. The drive is now transmitted from shaft 1 through gear 10 to gear 15 and through its sleeve to gear 16 and the driving elements of clutch 5. Gears 16 and 13 being the same size, the sleeve carrying gear 13 and the driving elements of clutch 4 are driven at the same speed as those of clutch 5. Clutches 4 and 5 being engaged the shafts 2 and 3 are driven, but, as may be seen by following the drive on the diagram, the resultant direction is opposite to that of the forward speeds.

(f) High Reverse: With gear 10 still in mesh with gear 15, both clutch hand levers are pushed forward, disengaging clutches 4 and 5 and engaging clutches 6 and 7. The drive is now transmitted from gear 15 to gear 14 and the driving elements of clutch 7, and also through sleeve to gear 16, then to gear 13, through sleeve to gear 11 and then to gear 17 and the driving elements of clutch 6. Clutches 6 and 7 being engaged, the shafts 2 and 3 are driven in the same direction as for low reverse but at a higher speed, due to the higher reduction from gears 15 and 11 to gears 14 and 17. Since gears 8 and 10 are the same size, the gear reductions in low and high reverse are the same as in low and second forward speeds respectively.

It is apparent from the description that, with any of the gears 8, 9 or 10 in mesh, by having the clutch hand lever on one side pushed forward while that on the other side is pulled back, the tracks on opposite sides may be driven at different speeds, the ratio of the speed of one track to the other being constant. It is equally apparent that either track may be allowed to run free while the other is driven either fast or slow. This transmission, however, does not provide for driving one track forward and the other backward.

Expansion of 240-mm. Howitzers, Model 1918 and Model 1918 MI.—In the September-October issue of ARMY ORDNANCE there appeared in the Artillery Division Notes an article analyzing the abnormal expansion that had taken place in practically all of the 240-mm. howitzers, Model 1918 and Model 1918 MI, in which an effort was made to show that a radial component of the tangential force necessary to rotate the shell was responsible for a unit pressure along the entire bore of the howitzer equal to about 5,000 pounds per square inch. This force in addition to that which was calculated as caused by the frictional resistance of the copper rotating band when accumulated upon the powder pressure showed that the howitzers were stressed above their elastic limit for approximately the entire travel of the projectile.

Since that article was issued, two howitzers which had not been previously proof fired were re-rifled by eliminating the .09 fillet at the bottom of the groove on the driving side and by making the driving side parallel to the radius. These two howitzers have recently been given the same proof firing as used in those others of the same model but without modified grooves, and it was found that at no place along the bore was there an enlargement of over .000½-inch, which amount is less than the probable error in using the star gauge instrument. Fourteen additional rounds or a total of twenty-one have caused an increase of only .001-inch. These results seem to bear out the theory that the radial component of the tangential effort was sufficient to stress the metal in the tube beyond its elastic limit when accumulative upon the other forces acting.

Twenty-five of the howitzers of the Model 1918 and 1918 MI have been given 7 additional proof firing rounds, making a total number for each howitzer of fourteen. The expansion of these latter howitzers has been approximately twice that of the average for the initial seven rounds of proof, which seems to show that the enlargement is progressive up to some unknown number of rounds which number seems to lie some place between thirty-five and fifty, as several howitzers have stopped expanding in the neighborhood of this number of rounds after the enlargement has reached approximately .015 inch.

Four additional howitzers, which have been proof fired seven rounds and which have expanded an amount equal to or in excess of the average as shown in the cut accompanying the previously mentioned article, are being re-rifled to eliminate the bottom fillet on the driving side and will be re-proofed to determine if there is any tendency of these four to continue to expand. If no expansion takes place, it is felt that definite results will have been obtained; first, that the fillet at the bottom of the groove on the driving side caused these howitzers to expand; and second, that the removal of this fillet will suspend the progressive enlargement due to future firing.

The standard practice of the Ordnance Department is to make the outside diameter of the rotating band of the shell .02 inch larger than the diameter across the bottom of the grooves. This excess metal introduces a marked radial force on the bore of the gun, thus increasing to the necessary force to overcome the static friction. Attention is invited to the fact that the present 240-mm. howitzers stop expanding when the increase in diameter has amounted to approximately the excess diameter of the rotating band over the diameter of the groove, which would seem to show that the past practice is a questionable one when considered solely from the tangential strength of the cannon.

Pneumatic Loader for 3-inch and 4.7-inch Anti-aircraft Gun Mount, Model 1920 E.—The pneumatic loader is employed to facilitate prompt loading at all angles of elevation of the gun, which has a range of 85 degrees. It is imperative that the round be fired immediately after the setting of the fuze and to accomplish this the fuze setter and tray are mounted convenient to one another and elevate with the gun.

The exacting duties performed by the loading mechanism for these mounts demand certain automatic safety features that must render the mechanism fool-proof and free when loaded, from any possibilities of premature action that might endanger the life of the gun crew and the service of the mount.

The loading cycle is started when the round is placed on the tray. The tripping of the fuze setter latch permits the fuze setter to ride forward to engage the fuze. Should the tray be swung with the fuze setter in this position, the high explosive shell would be thrown from the tray. To overcome this danger the tray is automatically locked by the action of the fuze setter in moving forward and is held fast until the fuze is free.

After setting the fuze, the tray is swung into line with the gun and the air inlet valve to ram the projectile home. At this point, it is necessary to insure against a too hasty operation of the rammer. This is done by employing a cam that engages the air inlet valve and prevents its turning until the shell is in line with the bore. This same cam causes the return of the rammer when the empty tray is swung clear of the gun. When the tray comes to rest, the valve is locked securely by the cam.

With the tray in line with the gun, the firing mechanism must be rendered inoperative. This is accomplished by the use of a coil spring, a plunger and a pawl on the tray shaft. When the tray swings into line with the gun, the plunger obstructs the movement of the firing mechanism until the empty tray, swinging clear of the gun, catches the plunger, compresses the spring and clears the path of the firing mechanism, thereby completing the loading cycle.

The mechanism involved in the loading must be such as will cause the gunners no inconvenience or delay, as the rate of firing must average about twenty rounds per minute. When the time consumed in setting this number of fuzes is added to the actual loading time, the rigid specifications for the loader can be appreciated.

Watertown Arsenal Notes

Method of Loading 16-inch Howitzers and Guns on Barbette Carriages.—Rapidity of fire is not only dependent upon the time consumed in laying the piece in elevation and azimuth, but also upon the cycle of loading. For smaller guns, or when fixed ammunition is used and the loading is done by hand, the problem is comparatively easy, but when it becomes necessary to rapidly load a 16-inch gun or howitzer, means must be provided by which power can be applied to quickly bring home the projectile and the powder charge.

Taking the case of the 16-inch gun where a projectile of 2,340 pounds in weight and 850 pounds of powder in four sections have to be rammed home, the Seacoast Carriage Section of the Artillery Division has devised a power rammer, one of which recently has undergone a test at the Watertown Arsenal, and after successfully ramming a dummy projectile of the weight of the service projectile 232 times, the advantage of this means of loading was clearly demonstrated.

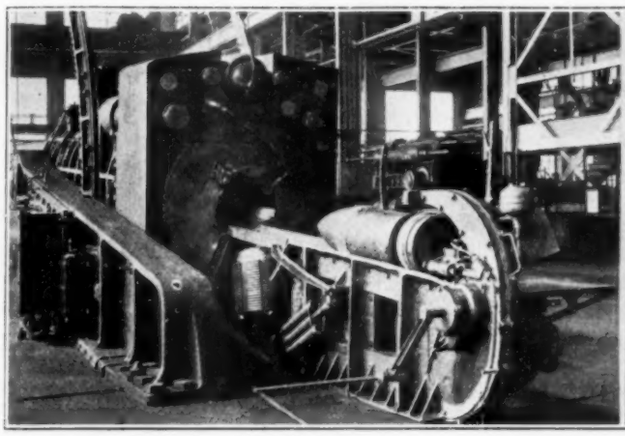


Fig. 1

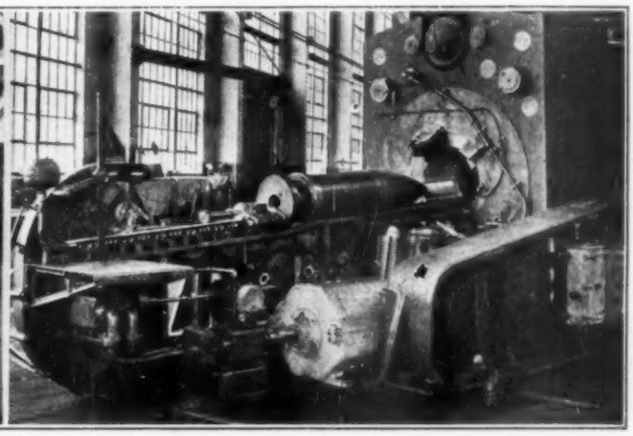


Fig. 2

In Figures 1, 2 and 3, the power rammer is shown in various views and during the different positions in the cycle of operation. In Figure 1, the projectile is ready to be sent forward, and in Figure 2, the projectile is shown partly on the rammer frame proper and partly on the spanning tray ready to enter the gun. On Figure 3 is shown the spanning tray in the retracted position so as to permit of closing breech block, the projectile and the powder being already brought to the correct position in the chamber of the gun.

Besides the power rammer, used for the purpose of loading, means must also be provided by which the projectile and the powder bags can readily be brought to the rammer tray, and for that purpose the arrangement shown on Figure 4 has been devised. It consists of a shell car, a powder car similar to the shell car except that the body is different (not shown in Figure 4), a revolving shell table and shell parking table. The shell car, of a capacity of three 2,340-pound projectiles, is brought to position as shown in Figure 4 and the projectile rolled over rails to the revolving shell table where proper stops have been provided to prevent going beyond the limit of the table; then by releasing the rails between the shell car and the revolving table and rotating the table to come in a plane parallel to the parking table which is on an inclination, the projectile is rolled to position on the rammer. A somewhat similar cycle of operation is performed for the powder bags.

The maximum electric power consumed in 26 rammings was 29 KW. which was developed in half a second from the start, the average during the next 3½ seconds being 22½ KW. The total time in ramming 23½ feet was 5 seconds.

The rammer is secured at the rear of the carriage to the top of the racer, and the revolving shell table is located to the right, revolving in a pedestal which is supported by the floor beams on the working platform, and the parking table is fastened at one end to the rammer casing and at the other end near the revolving table supported by a bracket fastened to the working platform. Similarly the powder tray is attached to the left side of the rammer casing and supported also from the working platform.

The construction of the rammer is shown in Figure 5. It is made up of three cast steel sections bolted together and supported by a rammer base bracket. Each section is made in two parts with grooves on the inner surface to serve as a path for the rammer chain. The rammer chain consists of 62 links with an hydraulic buffer head at front end, the rear end being provided with a special stop link to prevent the chain from running beyond the sprocket and out of the case. The hydraulic rammer head was devised to relieve the shock in starting the shell if speed gear is thrown suddenly into high speed. The buffer has a total stroke of 2 inches and is returned to the initial position by means of springs.

The power for this rammer is obtained by a speed gear which in turn is operated by an electric motor. This motor develops 30 horsepower at 500 revolutions per minute. It runs at constant speed, is non-reversing, and is designed for 110-volt direct current circuit. The speed gear is of the Waterbury Tool Company's Type K, Size 10, and tested at the "B" end at 44 horsepower at 550 revolutions per minute, with oil pressure of 800 pounds per square inch. The service requirements are 32.5 horsepower at "B" end with oil pressure of 650 pounds per square inch when motor is delivering 46.4 horsepower at "A" end. The motor is coupled directly to the "A" end and is running at constant speed at all times. A by-pass valve, set to open at 650 pounds pressure per square inch, is connected to the "B" end by copper tubing to provide the necessary circuits for the oil. A spur gear assembled to the shaft on the "B" end meshes with the spur gear on the chain sprocket shaft.

The control of the speed gear is provided by means of a lever operating gearing and shaft which are connected with a detent located on the control shaft on the "A" end. To operate the speed gear with motor running, the control lever is moved forward from the neutral position unlocking the detent and rotating the control shaft on the "A" end, which in turn will set the tilting box located in the "A" end from its neutral position causing oil to be pumped to the "B" end, causing the "B" end shaft to rotate and thereby transmitting power to the sprocket shaft, thus starting the rammer chain forward.

To withdraw the rammer chain, the control lever is moved to the rear of the neutral position reversing the angle of the tilting box and causing the oil to flow in the opposite direction and thus reversing the rotation of the "B" end shaft. The speed of the rammer chain will increase as the movement of the control lever from its neutral position increases, or, in other words, as the angle of the tilting box in the "A" end is increased.

In case the electric-driven speed gear should be out of order or become damaged the ramming can be performed by hand power by throwing the power end out of gear and allowing the chain sprocket drive to be operated by means of hand cranks located on either side of the rear of the rammer case.

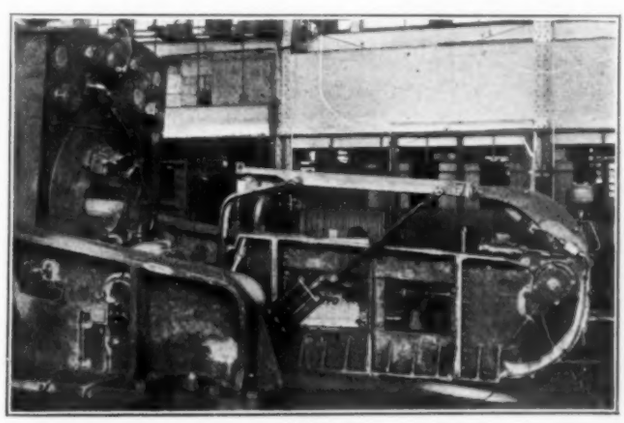


Fig. 3

To prevent operation of the speed gear, or rotation of the control shaft until the spanning tray is in its position in the breech of gun, the rear tray arm shaft is provided with the slotted disc which rotates as the spanning tray is pushed forward, bringing the slot in line with a pawl on the control shaft, thus allowing the pawl to pass through and the shaft to rotate.

The movement of the control lever from the neutral position in either direction is approximately 15 degrees and the rotation of the control shaft, thus allowing the pawl to pass through and the shaft to rotate.

The movement of the control lever from the neutral position in either direction is approximately 15 degrees and the rotation of the control shaft on the "A" end is .739 turns from neutral to full speed in either direction.

The spanning tray between the rammer and the breech of the gun is made of nickel supported by cast steel arms and

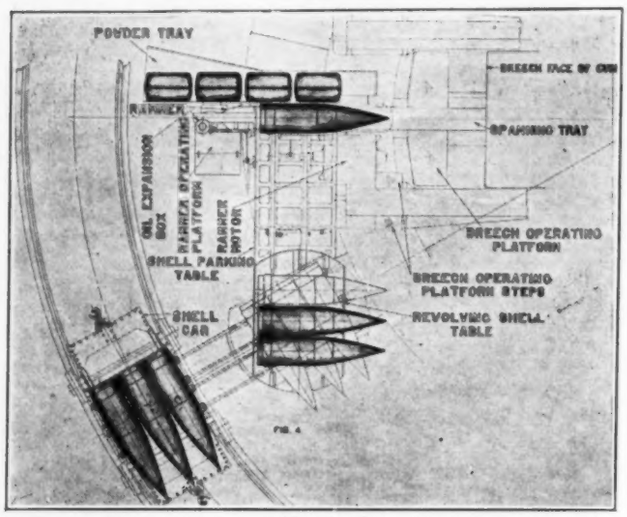


Fig. 4

levers and when not in use rests against the neck at the rear of the rammer case. The front and rear tray arms are connected with the counterbalance spring, the action of which is to assist in the release of the spanning tray from the loading position. When the tray is in the loading position, it is locked by an automatic latch located on the left side of the rammer case. To remove the spanning tray from the breech, the latch is tripped and the tray springs up out of the breech due to the action of the spring counterbalance, after which it is brought back to rest against the neck on the rear of the rammer case with a slight effort by hand.

The effort to start the projectile using hand power is 138 pounds on each crank having a leverage of 13 inches, the loading angle of the rammer being 4 degrees.

In ramming the projectile by the hand mechanism, 8 men were used, 4 on each crank, and the projectile was rammed home in 8 3-5 seconds, average. The time to set the spanning tray from repose to loading position was 2 3-5 seconds, the speed of motor not ramming being 511 revolutions per minute and this speed while ramming being 457 revolutions per minute.

The design and manufacture, as well as the performance of this mechanism whereby it is possible (with the rapid laying of the gun from extreme firing position of 65 degrees to the loading position of 4 degrees) to fire a shot anywhere between 45 seconds and a minute, will make the 16-inch gun or howitzer on the Barbette Carriage the most powerful weapons in existence and reflects the greatest credit of the officers, designers and the arsenal where manufacture was performed.

Investigation of Semi-steel Shell.—An investigation has recently been completed at the Watertown Arsenal which had for its object the determination of the best foundry practice for the production of 155 mm. semi-steel shells and also the determination of the effect of chemical composition on the physical properties of the metal.

Eleven heats were made, 20 shells per heat, a total of 220. From each heat 10 shells were finish machined and banded, 3 were finish machined and hydraulically tested to destruction, 1 was nicked through on one side and broken for examination of the fracture, 3 were cut up for physical test, and three were held as a laboratory reserve. The shells were machined to the dimensions prescribed for the 155 mm. H. E. Mark XVII Shell.

The semi-steel was made in a 42-inch cupola, two ladles being obtained in each heat, shells 1 to 10 being poured from the first ladle and shells 11 to 20 from the second ladle. The shells were cast in green sand molds, one shell to a flask, with dry sand cores, and were poured nose down. A "strainer plate" and "basin" were used in the top of the mold, which helped to give clean castings. Each shell casting was marked with a number indicating the heat in which it was made and the sequence in which it was made and the sequence in which it was poured. Thus the shell marked 7-87-11 was made from Heat 7-87 and was the 11th casting poured.

With each heat there were cast Tensile and Impact test specimens. The Tensile specimens were cast 8 inches long, with a 4-inch riser, 1¼-inches diameter in the center of the bar for a length of 4 inches. After cutting off the riser the bar was machined to 1.129 inches diameter (1 square inch cross-sectional area), gauge length 4 inches. The specification requires a tensile strength of 32,000 pounds per square inch minimum on this specimen. The impact specimens were cast 8 inches long, with a 4-inch riser, 1½ inches square. After cutting off the riser these bars were tested without further machining.

The test bars in the first two heats were molded in dry sand, and on all subsequent heats in green sand. The Tensile bars were cast two to a flask, gated at the bottom from the same sprue. The Impact bars were cast in the same manner, except in the last four heats, where four bars were cast to a flask instead of two.

In addition to the cast test bars, three shells from each heat were cut up for test. Two Tensile, two Impact and two Charpy bars were cut from each, taken 180 degrees apart and adjacent to the bottom of the cavity. The Tensile and Impact tests were machined to the dimensions previously noted, and the Charpy bars were standard.

The Impact test bars were broken on a machine conforming to requirements of Specification EA-182-2, from which the following is quoted:

"After removal of the riser the bar shall be placed on two angular supports, 6 inches apart, having edges with a radius of .08 inch and in turn supported by a one-piece anvil weighing at least 1750 pounds, resting on a concrete or other solid foundation. A weight of 25 pounds, having its bottom curved on a 2-inch radius, shall be caused to fall exactly on the middle of the test bar. The test shall begin with the weight at a height of 12 inches and shall be repeated, always striking the same face of the test bar, with the height of the weight increased by half-inch intervals until the bar breaks. The height of fall for causing rupture shall not be less than 18 inches, this height being measured from the upper surface of the bar to the lowest part of the testing weight."

Chemical analyses were made on samples taken from each ladle of each heat.

As each heat was made, data regarding it was noted by an observer. The temperature of the metal when tapping each ladle and pouring each shell was determined with a Leeds & Northrup Optical Pyrometer.

All the shells finish machined for ballistic test were subjected to an internal hydraulic pressure of 4500 pounds for 15 seconds without showing leakage or permanent expansion, as required by specifications. In addition, three shells from

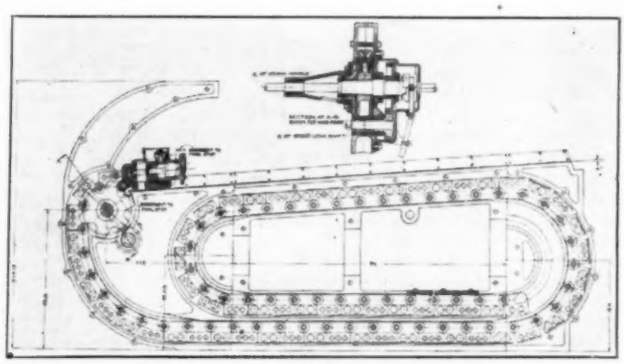


Fig. 5

each heat were tested hydraulically to destruction. These shells withstood as high as 12,700 pounds per square inch in one case and as low as 3600 pounds per square inch in another, although the average was around 9000 pounds per square inch.

The Brinell Hardness was obtained on each shell at a point half-inch below the bourrelet, and, on the shells which were cut up for physical test, from base to nose and in four positions around the base and bourrelet. A great variation was encountered in these readings, due to the fact that the hard-

Chemical Analyses							Representing			Average Physical Properties			Time in Mold (Hrs.)	Pouring Temp. (°C.)	Ratios							Remarks
Graphite	Comb. C.	Total C.	MN	Si	P	S	Impact Specimen	Ladle	Shells	Tensile	Impact	Charpy.			T.C.+ Si	C.C. / T.C.	Si / MN	T.C.+ Si / MN	T.C.+ Si / Si	T.C.+ Si+ MN	Si+ MN	T.C.+ Si+ MN / Si+ MN	
2.62	.63	3.25	.83	1.60	.272	.083	7-87-X1	2	1 to 10	31150	4	.....	2.1	1295	4.85	.194	1.93	5.84	3.03	5.68	2.43	2.34	
2.75	.65	3.40	.83	1.60	.272	.083	7-87-X3	2	1 to 10		1	.....	2.1	1295	5.00	.191	1.93	6.03	3.13	5.83	2.43	2.40	
2.62	.73	3.35	.73	1.35	.233	.091	7-87-XX1	3	11 to 20	30000	9	.....	1.8	1310	4.70	.218	1.85	6.44	3.48	5.43	2.08	2.61	
2.51	.59	3.10	.83	1.60	.272	.083	7-87-1A	2	1	25800	5	1.48	1.8	1323	4.70	.191	1.93	5.66	2.94	5.53	2.43	2.28	
2.48	.72	3.20	.73	1.35	.233	.091	7-87-11B	3	11	27450	6	1.66	17.0	1347	4.55	.225	1.85	6.24	3.37	5.28	2.08	2.54	
2.46	.54	3.00	.73	1.35	.233	.091	7-87-19A	3	19	23850	4	1.66	16.8	1312	4.35	.180	1.85	5.96	3.22	5.08	2.08	2.44	
2.56	.69	3.25	1.37	1.43	.098	.072	7-88-X3	3	1 to 10	25450	2	.....	1.1	1340	4.68	.212	1.04	3.42	3.28	6.05	2.80	2.16	
2.69	.66	3.35	1.37	1.43	.098	.072	7-88-X4	3	1 to 10		11	.....	1.1	1340	4.78	.197	1.04	3.49	3.34	6.15	2.80	2.20	
2.63	.62	3.25	1.12	1.50	.097	.070	7-88-XX1	4	11 to 20	28880	2	.....	1.0	1237	4.75	.191	1.34	4.24	3.17	5.87	2.62	2.24	
2.65	.70	3.35	1.37	1.43	.098	.072	7-88-1B	3	1	26850	6	1.62	1.0	1333	4.78	.209	1.04	3.49	3.34	6.15	2.80	2.20	
2.55	.75	3.30	1.12	1.50	.097	.070	7-88-11A	4	11	28450	9	1.61	0.8	1338	4.80	.227	1.34	4.29	3.20	5.92	2.62	2.26	
2.57	.63	3.20	1.12	1.50	.097	.070	7-88-19A	4	19	26850	7	1.48	16.3	1257	4.70	.197	1.34	4.20	3.14	5.82	2.62	2.22	
.55	2.70	3.25	.70	.73	.098	.115	7-89-XX1	4	11 to 20	.....	1	.....	1.5	1275	3.98	.831	1.04	5.69	5.45	4.68	1.43	3.28	
2.41	.69	3.10	.80	.90	.108	.087	7-89-1A	3	1	27650	13	1.52	2.1	1347	4.00	.223	1.13	5.00	4.44	4.80	1.70	2.82	*
2.30	.80	3.10	.70	.73	.098	.115	7-89-11A	4	11	29800	12	1.43	4.5	1318	3.83	.258	1.04	5.47	5.25	4.53	1.43	3.17	*
2.35	.80	3.15	.70	.73	.098	.115	7-89-19A	4	19	30900	11	1.48	4.5	1267	3.88	.254	1.04	5.56	5.32	4.58	1.43	3.20	*
2.62	.58	3.20	.96	1.43	.100	.069	7-90-X3	2	1 to 10	31950	4	.....	1.5	1390	4.63	.181	1.49	4.82	3.24	5.59	2.39	2.34	
2.47	.88	3.35	.96	1.43	.100	.069	7-90-X6	2	1 to 10		9	.....	1.5	1390	4.78	.263	1.49	4.98	3.34	5.74	2.39	2.40	
2.65	.63	3.28	.72	1.35	.084	.091	7-90-XX4	3	11 to 20	31460	13	.....	1.3	1375	4.63	.192	1.88	6.43	3.43	5.35	2.07	2.58	*
2.67	.70	3.37	.72	1.35	.084	.091	7-90-XX6	3	11 to 20		5	.....	1.3	1375	4.72	.208	1.88	6.56	3.50	5.44	2.07	2.63	
2.41	.84	3.25	.96	1.43	.100	.069	7-90-1B	2	1	25450	5	2.04	1.5	1386	4.68	.258	1.49	4.88	3.20	5.64	2.39	2.36	
2.47	.68	3.15	.72	1.35	.084	.091	7-90-19B	3	19	26850	5	1.81	1.3	1353	4.50	.216	1.88	6.25	3.33	5.22	2.07	2.52	
2.82	.68	3.50	.70	1.35	.128	.091	7-91-X2	2	1 to 10	26970	10	.....	1.5	1340	4.85	.195	1.93	6.93	3.59	5.55	2.05	2.71	*
2.67	.83	3.50	.70	1.35	.128	.091	7-91-X6	2	1 to 10		4	.....	1.5	1340	4.85	.237	1.93	6.93	3.59	5.55	2.05	2.71	
2.84	.63	3.47	.94	1.35	.139	.107	7-91-XX1	3	11 to 20	28420	4	.....	1¼	1385	4.82	.182	1.44	5.13	3.57	5.76	2.29	2.52	
2.70	.80	3.50	.94	1.35	.139	.107	7-91-XX2	3	11 to 20		9	.....	1¼	1385	4.85	.228	1.44	5.16	3.59	5.79	2.29	2.53	
2.55	.60	3.15	.70	1.35	.128	.091	7-91-1A	2	1	24100	10	1.71	1.5	1333	4.50	.191	1.93	6.43	3.33	5.20	2.05	2.54	
2.70	.75	3.45	.94	1.35	.139	.107	7-91-11B	3	11	22450	6	1.52	1¼	1381	4.80	.218	1.44	5.11	3.56	5.74	2.29	2.51	
2.60	.60	3.20	.94	1.35	.139	.107	7-91-19B	3	19	22500	8	1.52	1¼	1318	4.55	.188	1.44	4.84	3.37	5.49	2.29	2.40	
2.95	.55	3.50	.72	1.38	.310	.101	7-92-X4	2	1 to 10	26020	10	.....	1.7	1290	4.88	.157	1.92	6.77	3.54	5.60	2.10	2.67	
2.85	.80	3.65	.72	1.38	.310	.101	7-92-X5	2	1 to 10		2	.....	1.7	1290	5.03	.219	1.92	6.99	3.64	5.75	2.10	2.74	
2.95	.60	3.55	.81	1.38	.335	.095	7-92-XX4	3	11 to 20	26460	1	.....	1.5	1315	4.93	.169	1.70	6.08	3.58	5.74	2.19	2.62	
2.90	.70	3.60	.81	1.38	.335	.095	7-92-XX5	3	11 to 20		5	.....	1.5	1315	4.98	.195	1.70	6.14	3.61	5.79	2.19	2.64	
2.77	.38	3.15	.72	1.38	.310	.101	7-92-1B	2	1	20500	5	1.53	1.7	1343	4.53	.121	1.92	6.29	3.28	5.25	2.10	2.50	
2.82	.55	3.37	.81	1.38	.335	.095	7-92-11A	3	11	21800	2	1.11	1.5	1358	4.75	.163	1.70	5.87	3.44	5.56	2.19	2.54	
2.89	.61	3.50	.81	1.38	.335	.095	7-92-19A	3	19	21450	4	1.21	1.5	1312	4.88	.174	1.70	6.02	3.54	5.69	2.19	2.60	
.....	.....	3.10	.45	1.15	.128	.094	.....	2	1 to 10	.....	.....	.....	.....	1315	4.25	.....	2.56	9.45	3.70	4.70	1.60	2.94	
2.14	1.06	3.20	.46	1.10	.127	.092	7-93-XXX1	3	11 to 20	8690	5	.....	2.5	1315	4.30	.331	2.39	9.35	3.91	4.76	1.56	3.05	
1.49	1.51	3.00	.46	1.10	.127	.092	7-93-XXX3	3	11 to 20		1	.....	2.5	1315	4.10	.504	2.39	8.90	3.73	4.56	1.56	2.93	
1.96	1.14	3.10	.51	1.20	.126	.087	7-93-XXXX2	4	Bombs.	.....	3	.....	.....	.....	4.30	.368	2.35	8.43	3.58	4.81	1.71	2.82	
2.02	.98	3.00	.45	1.15	.128	.094	7-93-1A	2	1	30700	13	8.30	2.5	1377	4.15	.327	2.56	9.22	3.61	4.60	1.60	2.88	*
2.13	.92	3.05	.46	1.10	.127	.092	7-93-11A	3	11	29000	13	8.30	2.7	1347	4.15	.302	2.39	9.01	3.77	4.61	1.56	2.96	*
2.12	.88	3.00	.46	1.10	.127	.092	7-93-19B	3	19	28750	9	8.76	2.7	1282	4.10	.293	2.39	8.90	3.73	4.56	1.56	2.92	
1.87	1.33	3.20	.37	1.35	.161	.117	7-96-XX1	4	1 to 10	33550	1	.....	14.5	1330	4.55	.416	3.65	12.3	3.37	4.92	1.72	2.86	
2.50	.77	3.27	.37	1.35	.161	.117	7-96-XX5	4	1 to 10		13	.....	14.5	1330	4.62	.236	3.65	12.5	3.42	4.99	1.72	2.90	*
2.03	1.12	3.15	.31	1.35	.145	.119	7-96-XXX2	5	11 to 20	20800	1	.....	14.3	1330	4.50	.356	4.36	14.5	3.33	4.81	1.66	2.90	
1.89	1.36	3.25	.31	1.35	.145	.119	7-96-XXX4	5	11 to 20		8	.....	14.3	1330	4.60	.418	4.36	14.8	3.41	4.91	1.66	2.96	
2.18	.87	3.05	.37	1.35	.161	.117	7-96-1A	4	1	27600	13	1.57	14.5	1358	4.40	.285	3.65	11.9	3.26	4.77	1.72	2.78	*
2.14	.96	3.10	.31	1.35	.145	.119	7-96-11A	5	11	27450	7	1.34	14.3	1372	4.45	.310	4.36	14.4	3.30	4.76	1.66	2.87	
1.90	1.05	2.95	.31	1.35	.145	.119	7-96-19A	5	19	30400	3	1.30	14.3	1307	4.30	.336	4.36	13.9	3.18	4.61	1.66	2.78	
1.98	1.17	3.15	.53	1.35	.316	.092	7-97-X3	5	1 to 10	.....	7	.....	16.3	1340	4.50	.372	2.55	8.49	3.33	5.03	1.88	2.68	
2.60	.50	3.10	.53	1.35	.316	.092	7-97-X5	5	1 to 10		1	.....	16.3	1340	4.45	.161	2.55	8.39	3.30	4.98	1.88	2.65	
2.58	.52	3.10	.35	1.18	.404	.098	7-97-XX1	6	11 to 20	27150	4	.....	16.0	1315	4.28	.168	3.37	12.2	3.63	4.63	1.53	3.03	
2.05	1.08	3.13	.35	1.18	.404	.098	7-97-XX3	6	11 to 20		13	.....	16.0	1315	4.31	.345	3.37	12.3	3.65	4.66	1.53	3.05	*
2.46	.34	2.80	.53	1.35	.316	.092	7-97-9B	5	9	27550	6	1.11	16.3	1307	4.15	.121	2.55	7.83	3.08	4.68	1.88	2.49	*
1.86	.89	2.75	.35	1.18	.404	.098	7-97-11B	6	11	31700	13	1.25	16.0	1318	3.93	.324	3.37	11.2	3.33	4.28	1.53	2.80	
2.05	.70	2.75	.35	1.18	.404	.098	7-97-19A	6	19	31000	3	1.25	16.0	1252	3.93	.255	3.37	11.2	3.33	4.28	1.53	2.80	
1.89	1.16	3.05	.36	1.40	.362	.142	7-98-X1	7	1 to 10	.....	5	.....	17.0	1350	4.45	.380	3.89	12.4	3.18	4.81	1.76	2.73	
1.90	1.25	3.15	.36	1.40	.362	.142	7-98-X4	7	1 to 10		2	.....	17.0	1350	4.55	.397	3.89	12.6	3.25	4.91	1.76	2.79	
1.89	1.31	3.20	.37	1.40	.392	.141	7-98-XX1	8	11 to 20	29700	1	.....	16.5	1240	4.60	.409	3.79	12.4	3.29	4.97	1.77	2.81	
1.92	1.23	3.15	.37	1.40	.392	.141	7-98-XX4	8	11 to 20		11	.....	16.5	1240	4.55	.390	3.79	12.3	3.25	4.92	1.77	2.78	*
1.89	.91	2.80	.36	1.40	.362	.142	7-98-1A	7	1	30600	13	1.21	17.0	1391	4.20	.325	3.89	11.7	3.00	4.56	1.76	2.59	*
1.98	.87	2.85	.37	1.40	.392	.141	7-98-11B	8	11	29350	12	1.21	16.5	1297	4.25	.305	3.79	11.5	3.04	4.62	1.77	2 61	*
2.04	.71	2.75	.37	1.40	.392	.141	7-98-19A	8	19	29450	5	1.39	16.5	1247	4.15	.258	3.79	11.2	2.96	4.52	1.77	2.56	
2.39	.85	3.15	.52	1.10	.205	.097	7-99-XX3	4	1 to 10	20180	13	.....	16.5	1345	4.25	.270	2.12	8.17	3.87	4.77	1.62	2.95	
2.32	.68	3.00	.52	1.10	.205	.097	7-99-XX4	4	1 to 10		9	.....	16.5	1345	4.10	.227	2.12	7.88	3.73	4.62	1.62	2.85	
1.85	1.20	3.05	.59	1.05	.147	.090	7-99-XXX3	5	11 to 20	23120	3	.....	16.5	1300	4.10	.393	1.78	6.95	3.91	4.69	1.64	2.86	
1.89	1.31	3.20	.59	1.05	.147	.090	7-99-XXX5	5	11 to 20		1	.....	16.5	1300	4.25	.409	1.78	7.21	4.05	4.84	1.64	2.95	
2.26	.79	3.05	.52	1.10	.205	.097	7-99-1A	4	1	29450	11	1.75	16.5	1377	4.15	.259	2.12	7.98	3.77	4.67	1.62	2.88	*
2.21	.74	2.95	.59	1.05	.147	.090	7-99-11A	5	11	30300	11	1.53	16.5	1340	4.00	.251	1.78	6.78	3.81	4.59	1.64	2.80	*
2.12	.78	2.90	.59	1.05	.147	.090	7-99-19B	5	19	27250	10	1.72	16.5	1287	3.95	.269	1.78	6.70	3.77	4.54	1.64	2.78	*
A.	B.	C.	D.	E.	F.	G.	H.	I.	J.	K.	L.	M.	N.	O.	P.	Q.	R.	S.	T.	U.	V.	W.	

ness of the metal decreases as we progress from the surface of the casting toward the inner metal. However, it was demonstrated that the nose of the casting is always considerably harder than the base.

The castings which were slit through on one side and then broken open showed large coarse-grained metal at the base of the shell grading up to finer grained metal at the nose, and also showed finer grain at the outside of the shell than next to the cavity.

The table shows data observed under this experiment. The following remarks are made in explanation of it:

1. The carbon analyses in Columns A, B and C were made on samples taken from the impact test bars noted in Column H.
2. Analyses for Mn, Si, P and S are quoted as detefmined on ladle samples.
3. In Column H separately cast Impact test bars bear the suffix X1, XX2, etc.; Impact tests cut from shells bear the suffix 1A, 11A, 19A, etc.
4. Tensile figures (Column K) are averages.
5. Time in mold and pouring temperatures (Columns N and O) are quoted from the records of the several heats.
6. In the "Remarks" column asterisks have been placed after those tests which showed 10 blows or better on Impact test and 27,000 pounds or better on Tensile test..

The following conclusions are drawn from the data collected:

1. Mn may be as high as .80 per cent.
2. Si may be as high as 1.40 per cent.
3. P may be as high as .404 per cent.
4. S may be as high as .142 per cent.
5. Total carbon plus silicon may vary between 3.83 and 4.85 per cent.

6. Total carbon is generally lower in the shell than in the cast test bars from the same heat.
7. Physical properties exhibited by separately cast test bars are no measure of the properties of the metal in the shells themselves.
8. Two hours is sufficient time to hold shells in molds before stripping, one hour for test bars.
9. Pouring temperatures above 1325 degrees C. are preferable.
10. The Impact tests are inclined to be erratic.
11. The Charpy tests are unreliable. The high Charpy values found on the test shells from heat 7-93 are anomalous.

The ratios in columns P. and W., inclusive, were worked out in the hope that some fixed relationship might be discovered which would serve as a method for foundry control. No such relationship is apparent, although best tensile and impact test results were obtained when the ratio C C-T.C. (combined carbon divided by total carbon) lies between .250 and .350, average .300.

Frankford Arsenal Notes

Aiming Mirror, Type A.—The Aiming Mirror, Type A, Figure 1, is for use in laying gun carriages in azimuth in relation to a target or aiming point, which is accomplished by reflecting the image of the target or aiming point such as to be viewed in the telescope on the gun carriage. With the mirror set and the reading of the telescope noted, it is obvious that the gun carrage can be kept trained in the desired angular relation to the object just as accurately as if the object were viewed directly through the telescope.

The aiming mirror will be found useful to the artilleryman, especially when the battery is emplaced below the level of the surface of the ground.

It consists of a heavy wooden base (1) upon which is mounted a bronze tripod (2) into which is inserted the vertical column or mast (3), one-meter high, which supports the mirror support bearing (5). The tripod legs are fitted with leveling screws (6) which permits leveling of 5 degrees.

The center of the tripod is bored to receive a tapered steel end which supports the mast (3). The mast is constructed of tubing and contains a keyway which serves as a guide for the mirror support bearing (5).

The mirror support bearing (5) is bored to slide snugly along the mast (3) and is fitted with a key which engages the keyway on the mast and prevents its rotation. A clamping screw (20) is provided for clamping at the desired height. The upper portion of the bearing contains a tapered hole for receiving the mirror support. A German silver azimuth scale (7) graduated clockwise in hundreds of mils from 0 to 6400 in a half-circle and repeated for the other half, is attached to the uppermost surface of the bearing (5).

The lower end of the mirror support (8) is tapered to fit the mirror support bearing snugly and is free to rotate. A clamping screw (9) is provided to clamp the mirror in any desired position. Two levels (10) at right angles to each other are provided for leveling.

The mirror (12) is made of three pieces of stellite (metal) 4 by 6 by 5-16th inches thick, ground optically flat and highly polished. The abutting edges are ground accurately to reduce the appearance of the joints.

The mirrors are mounted in a steel channel-shaped frame (11) and held firmly by means of four clamping springs (13) against eight small flat buttons attached to the frame directly underneath the ends of the springs. These buttons are machined accurately so as to form a theoretical flat surface.

The mirror frame (11) is constructed such that it can be slid longitudinally in the hinged portion (14) of the mirror support, six inches on each side of the center. A thumb nut (15) is provided for leveling the mirror in respect to the axis of rotation. The level (16) attached to the hinged portion is provided for this purpose. The frame containing the mirror can be readily removed from the mirror support.

To set up the aiming mirror, place the wooden support in the desired position; place the tripod with the leveling screws run up upon the board, and move until the ball-shaped stud (17) engages the ball socket (18) which is secured to the center of the board, then rotate the leveling screws until the ball is firmly pressed against the upper portion of the ball socket and proceed to level, always keeping the leveling screws run out to prevent motion between ball and ball socket.

To Operate.—Release the lower spindle clamp (19) and with the mirror azimuth scale set at the desired position, rotate the mast until the reflection of the target can be seen through the telescope, then clamp. The lower spindle motion is primarily for orienting the mirror. The upper or mirror motion is for detecting the angular movements of the gun in relation to target or aiming point.

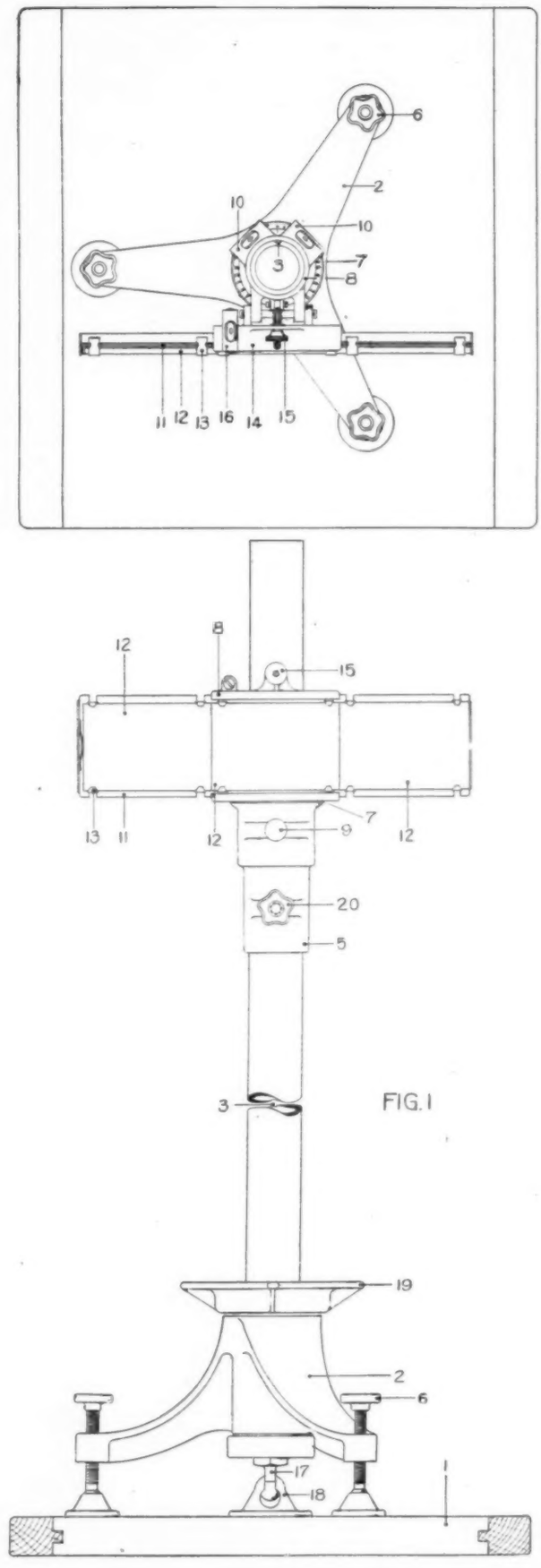
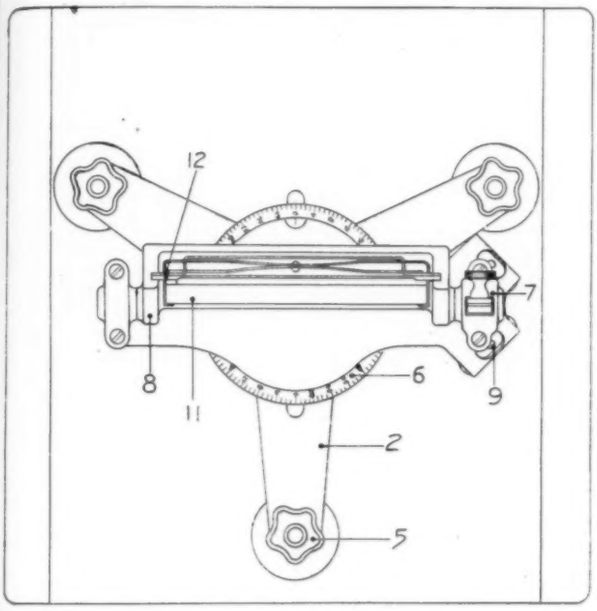


FIG. 1

Aiming Mirror, Type B.—The Aiming Mirror, Type B, Figure 2, is for the same use as the Aiming Mirror Type A, and is practically the same in construction.

It consists of a heavy wooden base (1) upon which is



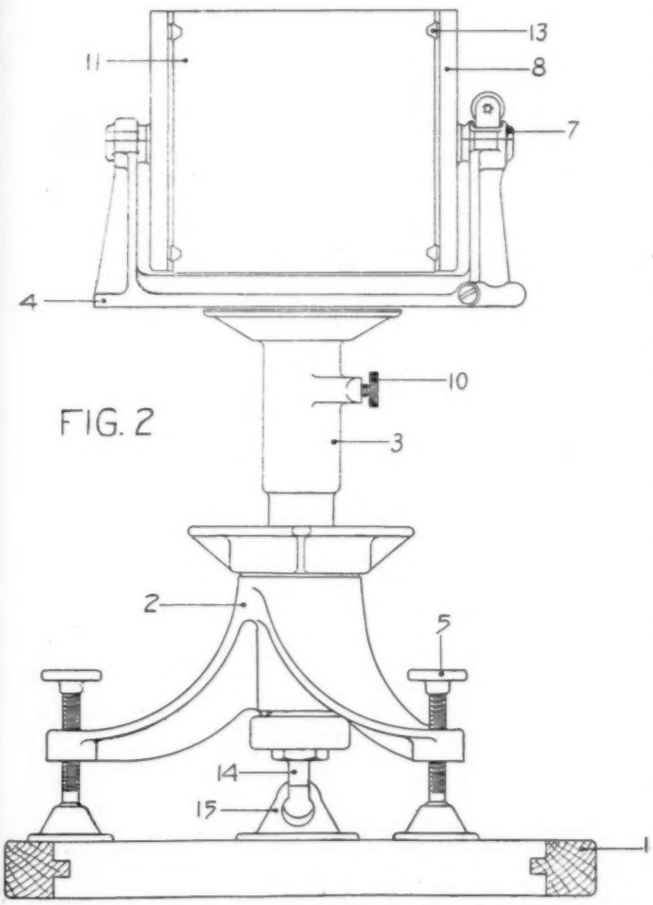


FIG. 2

mounted a bronze tripod (2) into which is inserted a short vertical spindle (3), the upper end of which forms a bearing for the mirror support (4). The tripod legs are fitted with leveling screws (5) which permit leveling of 5 degrees.

The lower end of the vertical spindle (3) is tapered and fits snugly into the tripod. The upper end is bored to receive the mirror support (4). A German silver scale (6) graduated clockwise in one hundred mil divisions and numbered every 400 mils, from 0 to 6400, in half a circle and repeated for the other half, is fastened to the top surface.

The tapered end of the mirror support (4) fits snugly into the socket in the upper portion of the vertical spindle (3). The two upright ends (7) form bearings for the trunnions on the mirror frame (8). Two levels (9) at right angles to each other are provided for leveling. A clamping screw (10) for securing the mirror in the desired angular position is also provided.

The mirror (11) is made of stellite (metal) 8 by 8 by .625 inches thick, ground optically flat and highly polished. It is mounted in a steel channel-shaped frame (12) and held firmly by means of two clamping springs (13) against four small buttons attached to the frame directly underneath the ends of the springs. These buttons are machined accurately to height and the surfaces are parallel to each other so as to form a theoretical flat surface. The frame containing the mirror can be readily removed from the mirror support.

To set up the aiming mirror, place the wooden support in the desired position, then place the tripod with the leveling screws run up upon the board and move until the ball-shaped stud (14) engages the ball socket (15) which is secured to the center of the board, then rotate the leveling screws (5) until the ball is firmly pressed against the upper portion of the ball socket, then proceed to level. Always keep the leveling screws run out to prevent motion between ball and ball socket.

To Operate.—Release the lower spindle clamp and with the mirror azimuth scale set at the desired position, rotate the mast until the reflection of the target can be seen through the telescope, then clamp. The lower spindle motion is primarily for orienting the mirror. The upper or mirror motion is for detecting the angular movements of gun in relation to target or aiming point.

The instruments should always be set up at a sufficient distance from the muzzle of the gun to avoid flying particles striking the mirror and finally destroying the reflective definition of the polished surface.

Wooden packing chests containing all the parts of the aiming mirrors and accessories are provided for safe transportation, except that the wooden supports are provided with metal handles for carrying and will not be stored in the carrying chest, due to their bulk.

Aiming Mirrors, somewhat similar in construction to those described above, were used by the armies in the past war. The mirrors of these instruments were constructed of silver-backed plate glass and a great deal of difficulty was experienced in producing optically flat mirrors; in order to overcome this difficulty, the use of stellite metal has been resorted to.

Stellite is a cast metal of exceptional hardness and requires no heat-treatment; its temper is inherent and permanent. It will not rust, stain or tarnish, and is impervious to practically all chemicals and acids. It takes a permanent white polish and its color is not affected by the usual high temperatures.

When properly ground and polished, it will produce a reflecting surface with excellent definition and, although more expensive than glass and more troublesome to work, it has a great advantage over glass, inasmuch as it can be handled more roughly and also will retain its shape better than glass under the usual climatical conditions.

ERRATA.—In the March-April issue of ARMY ORDNANCE, under Frankford Arsenal Notes on page 310, column 2, paragraph 1, it is stated that the Target Computer is constructed to 20,000 yards to the inch, which should read "2,000 yards to the inch."

Rock Island Arsenal Notes

Hydro-pneumatic Packings.—The packings used in the hydro-pneumatic recoil mechanisms consist of a rubber filler, a chrome leather packing and silver cup rings. The leather and silver cup rings form the wearing surface of the packing which brings them in contact with the highly polished cylinder walls and piston rods.

It is found that after the mechanisms have been in storage for an extended period of time the surfaces of the cylinders and rods which are in contact with the packings are discolored and the polish destroyed, also the cup rings are badly pitted and in many cases the thin flanges which form the bearing surface are eaten through, leaving a saw-tooth edge which

will not produce a tight joint. This requires the cup rings to be replaced when the mechanism is disassembled for inspection.

It is supposed that the sulphur in the rubber and acids in the chrome leather produce the above results. After numerous experiments had been made it was found that a coating of shellac on the surface of the silver rings which are in contact with the rubber and leather prevents the pitting of the rings, and that tinfoil placed over the leather packing prevents the injury to the polished walls and rods.

A St. Chamond hydro-pneumatic recoil mechanism for the 75 mm. Gun Carriage, Model 1916MI, is being assembled with the tinfoil coverings over all moving packings. This mechanism will be gymnasticated one thousand times under careful observation to discover any leaking or wearing of the packings and will then be sent to Aberdeen Proving Ground for firing tests.

The tinfoil packing is further useful in the pneumatic equilibrator, which was described on page 352 of the May-June, 1921, issue of ARMY ORDNANCE, as it greatly reduces the packing friction which acts as a drag in both elevating and depressing the piece.

Chrome Molybdenum Steel Rivets.—Some of the latest designs of gun carriages are using high-grade alloy steel for trail flasks in order to reduce the weight to the minimum. The question of steel for rivets suitable to use with these flasks has been the subject of an investigation as to the desirability of nickle steel or chrome molybdenum steel.

The heads of the nickle steel rivets have a tendency to fly off in cooling, which precludes their use.

The chrome molybdenum steel rivets tested indicated that this alloy is superior to nickle steel for this purpose. The rivets drive hot as easily as ordinary commercial steel rivets, set tight and do not exhibit the tendency to lose their heads.

In the test of a .75-inch rivet, it failed in single shear at 70,000 to 75,000 pounds per square inch.

Panoramic Sight Case.—Spring suspended sight cases, for carrying the panoramic sight with the carriage, have a socket in which the dovetail on the shank is placed. The upper part of the sight is retained by a flat spring of irregular outline. This spring has always been an undesirable feature, as it is somewhat difficult to manufacture and occasionally breaks when in use.

A new fastening has been designed which eliminates the spring and holds the sight in place by a bell crank which is locked as the cover of the case is closed.

Cases equipped with this fastening will accommodate panoramic sights, Models of 1904, 1915 and 1917.

Watervliet Arsenal Notes

Copper Removing Tool for 155 mm. Gun, Model of 1918 and 1918 MI.—This Arsenal has recently completed the manufacture of a hand-operated tool for removing copper deposits from the rifling grooves in the 155 mm. Gun, Model of 1918 and 1918 MI. Experience in using various copper-removing tools in the past has met with but little success, owing principally to the tendency of the cutters to gouge the sides of the lands instead of freely following the grooves. Difficulties were also met in adjusting the cutters sideways, when found necessary to do so to meet slight inequalities in the spacing of the grooves.

In the head under discussion, the tendency of the cutters to gouge has been overcome by mounting the tool carrying head a running fit on the shaft, supported by a ball thrust bearing, permitting the head to rotate freely, lubrication being made through an alemite grease cup in front end of shaft.

It will be noted from the accompanying illustrations that the tool head carries three tool holder housings 120 degrees apart, each of which carries a cutter holder and cutter, each cutter cleaning two grooves. Two of the housings are adjustable sideways by a set screw at each side of the housing, radial alignment being automatically controlled by the pivoting arrangement around the cutter holder housing bushing.

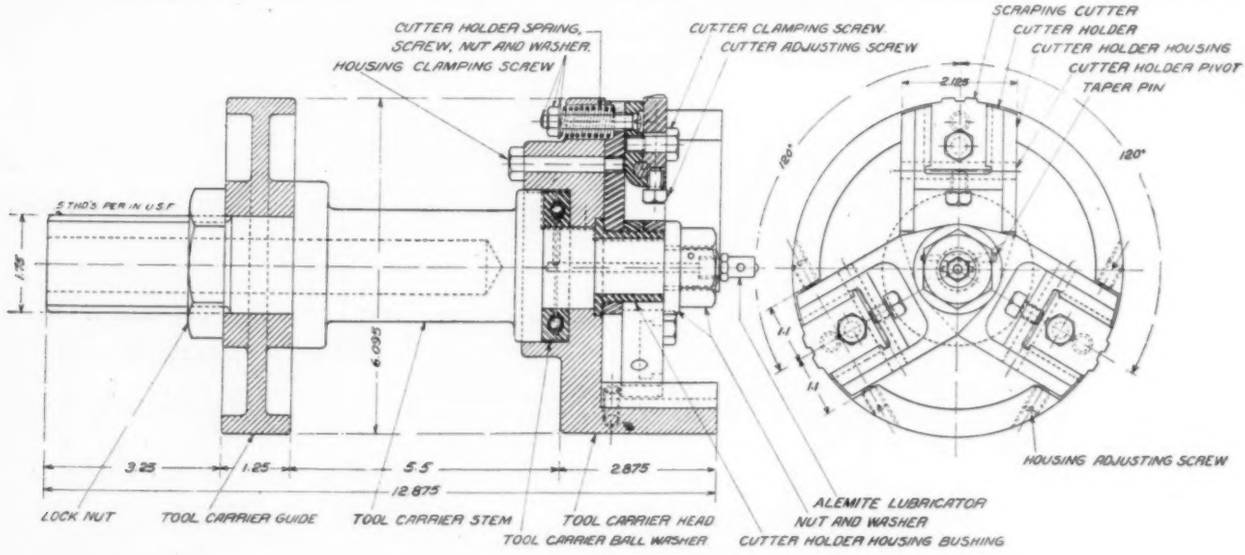
The rotating head carrying the tool also extends forward of the cutter, permitting the tool to enter the gun before the cutters engage the grooves, a feature lacking in previous designs. The cutter holders swing on a pivot in the housings, similar to a clapper box tool head, permitting withdrawal without breaking the cutters if head sticks in forward passage.

To the rear of the rotating head is another support of the same diameter called "Tool Carrier Guide," which serves to steady and prevent cramping of the tool. At the rear of this support the shaft is threaded to receive a coupling, which fits the regulation rammer stave for 6-inch gun.

The cutters are made of tool steel, hardened, and with just sufficient clearance to properly cut and at the same time guide themselves in the grooves. The fact that the head is free to rotate on the shaft is not influenced by the operator's grip on the rammer stave reduces to a minimum the tendency of the cutters to gouge the sides of the lands. This tool, after completion, was given a successful test in a 155 mm. Gun 1918 MI, in storage at this Arsenal, and was operated by three men.

Relining of 14-inch Gun No. 1, Model 1910.—Fourteen-inch Gun No. 1, Model 1910, which was recently returned to this Arsenal, is the first to be relined of the guns which were originally built with a double tube, or removable liner, so that in relining the liner could be removed by unshrinking rather than by boring out a portion of the old tube to produce a new liner seat.

In the manufacture of the Model 1910 Guns, the gun was built upon the liner, i. e., the "B" Tube was first rough turned and finish bored for the liner, or "A" Tube, the liner seat having a taper of .005 on the diameter per inch of length. The liner was then turned to the prescribed shrinkage of .005 on the diameter from the breech end of the shoulder and .008 on the diameter from the shoulder to the breech end. The tube and liner were next assembled the tube being heated to a maximum temperature of 800° F. and the tube dropped



Copper Removing Tool for 155-mm. Guns

over the liner, which was placed in a vertical position in the pit, breech end down.

After the tube was in place, water was applied at about 1 inch below the shoulder to ensure gripping of the liner at the shoulder and gradually cooling toward the muzzle. A shedder was provided below the point of first application of water to prevent seizing of the breech section, thereby forcing the liner off shoulder.

After shrinking, the bore of the assembled tube and liner was "telltaled" by chucking the muzzle end in a lathe, the breech end running free in a steady rest at a point about 2 feet from the breech end, in which position the "telltale" showed that the bore of the liner had a bend or runout of approximately .125 about 20 feet from the breech end. In order to reduce this runout as much as possible, the muzzle end was thrown in the chuck about .04. The exterior of the tube was re-spotted and turned to the prescribed dimensions for wiring.

The wire was then applied at a tension of 46,100 pounds per square inch on the breech end up to the location of the trunnion and at a tension of 60,000 pounds per inch from this point forward to the muzzle end, the bore being star-gauged at various steps of the winding operation to determine whether the calculated compression was being obtained. After the wire was assembled, the exterior was turned to permit the assembly of the exterior jackets and hoops which were then assembled in the usual order and the gun finish bored and rifled. Due to the distorting of the bore from the shrinking of the "A" and "B" Tubes previously mentioned and the assembly of the exterior members, the finish bore of the gun and the exterior of the liner were not concentric.

The calculated compression in the liner seat in the rear of the shoulder was .032 with the liner out. It is therefore evident that this portion of the liner taking into consideration the original shrinkage of .005, was actually subjected to a compression equal to a shrinkage of .037. To break a shrinkage of this magnitude by the usual method of heating the gun and refrigerating the liner was not thought to be practicable, inasmuch as it would require a difference in temperature between the liner and the tube of at least 350° F., to obtain which would require heating the gun to a temperature that might prove detrimental to the wire. It was, therefore, decided to heat the gun to 400° F., refrigerate the liner, and attempt its removal with the aid of a horizontal hydraulic press. In order to properly refrigerate the liner, the breech end of the gun was equipped with a plug through which passed eight 2¼-inch inlet pipes for the water and two 2¼-inch steam outlet pipes. The muzzle was provided with a plug which was equipped with one 2¼-inch steam outlet pipe. After heating the gun to the above temperature, it was placed in the hydraulic press, water turned on and the muzzle end subjected to a pressure of 30 tons which was gradually brought up to 700 tons in 1½ minutes; this produced no movement of the liner.

A second attempt was made by heating the gun to 700° F., again placing the gun in the hydraulic press, refrigerating the liner as before, and at the end of one minute a pressure of 90 tons was applied at the muzzle end of the liner and held for three minutes, when the liner broke loose, the pressure dropping to 50 tons. The press was kept in motion with pressures ranging from 40 to 125 tons, forcing the liner out a distance of 3 feet 6 inches, when it was found that the liner was totally disengaged.

After the removal of the liner, the bore was carefully inspected and numerous scores were found on the liner seat and liner surface, ranging in depth from 0 to .003, and in width .01 to .75. The liner seat in the gun was then carefully "telltaled" and was found to have a bow, or runout, of approximately .11 at 18 feet from the breech end, the exterior of the gun having a maximum runout of .04 at 20 feet from the breech end.

The liner seat of the gun was then carefully star-gauged at 10-inch intervals and it was found that the contraction of the bore over the original dimensions varied from .0135 at the breech end, gradually reducing to .005 at 10 inches from the breech endo the contraction of the remainder varying from .003 to .0095 as measured at 10-inch intervals. (See accompanying table.)

As the calculated compression of the liner seat was .032, it will be seen that a considerable portion of the compression in the bore of the gun with the liner removed has been lost, the cause of which has not as yet been determined.*

To definitely determine whether the loss of compression was due to the effect of heating the gun for the removal of the liner, or whether this compression had been lost prior to the removal of the liner due to stretching of the wire or other causes during the firing of the gun, the removal of the liner from another gun of the same model is being accomplished by boring, after the removal of which the bore of this gun will be carefully star-gauged to determine what changes, if any, have taken place therein.

The liner which was removed from the gun under discussion was carefully measured over the exterior and it was found that the same had taken a set varying from 0 to .005.

A new liner is being prepared for assembly to this gun and

Continued on Page 380

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Springfield Armory Notes

During the past year there has been under development at Springfield Armory, two distinct types of caliber .30 semi-automatic shoulder rifles. The design of one of these rifles is fundamentally based upon the design of the so-called Bang semi-automatic rifle which was tested by the Ordnance Department in 1912 or 1913. One model of this rifle was constructed and tested some months ago. A second model, incorporating certain improvements, is now ready for an Ordnance Department test. The other semi-automatic rifle being worked upon by Springfield Armory is known as the Garand semi-automatic rifle. Two models had previously been made and tested, and a third model, which it is believed is superior to the first two is now nearing completion. It is contemplated that as soon as possible, these two types of semi-automatic rifle will be subjected to a rigid Ordnance Department test for the purpose of determining the degree of perfection of the two designs and their further possibilities.

The combatant branches of the service are vitally interested in the successful development of the semi-automatic shoulder rifle weighing very little more than the present magazine shoulder rifle to displace the present service rifle or for use in conjunction therewith. It is claimed that a semi-automatic rifle will increase the fire power of the rifleman by making it possible for him to deliver a far more accurate fire because of the fact that with this type of weapon he can devote his whole attention to the aiming and firing of the piece, while with the present day magazine rifle, a portion of his attention and energy must be devoted to reloading the rifle after each shot by manipulating the bolt. In order that the value of the weapons of this character might be given some study by the Infantry, the Ordnance Department more than a year ago furnished twenty-five caliber .25 Remington auto-loading rifles, which had been equipped with a military type of stock and military sights, to the Infantry School, Fort Benning, Ga. On account of the limitations of the ammunition fired with this weapon, it was finally concluded that very little of value could be obtained from these weapons. In order that a semi-automatic weapon of the same fire power as the magazine rifle might be investigated by the Infantry and Cavalry, the Ordnance Department has just entered into a contract with the Auto-Ordnance Corporation for twenty caliber .30 Thompson semi-automatic rifles. This type of rifle has been tested with encouraging results several times by the Ordnance Department in conjunction with other designs. The Auto-Ordnance Corporation has agreed to furnish twenty of these rifles within eight months, and upon their receipt, ten will be sent to the Infantry School and ten to the Cavalry School. Whether this type of weapon in its present form is entirely suitable to meet rigorous service conditions, will be determined, at any rate it will be entirely practicable to develop the tactical possibilities with this type of arm, and it is hoped that this will be done. In the meantime, work will be continued by the Ordnance Department in the development of one or both of the two semi-automatic rifles first referred to, with the expectation that one or the other can be eventually perfected to such an extent that it will successfully meet all service requirements in a mechanical sense. The tactical usefulness of a weapon of this type, which is mechanically satisfactory, will naturally have to be determined by the branches of the service which will be equipped with the weapon.

Experiments were conducted to determine the practicability of removing obstructions in barrels by shooting them out with a cartridge from which the bullet had only been extracted. Rags, bullets, cleaning patches and other articles were placed in the barrel at different times and each was blown out with more or less ease. It was found that under favorable conditions obstructions could be removed by this method without injury to the barrel. However, should the obstruction fail to be removed the gas would be locked in the barrel under pressure and result in serious personal injury to the firer when the bolt was opened. It was concluded that the danger of injury, when the bolt was opened, to the personnel involved makes this method unsuitable for use.

A comparative test between the Browning Automatic Rifle and the Madsen Machine Rifle has been conducted. Final report on this test has been submitted to the Ordnance Office. General C. C. Williams, Colonel Bricker, Major O'Leary and Captain Jervey of the Ordnance Department were present at this test.

The anti-aircraft mounts developed at this Armory, both for the Browning Automatic Rifle and the Browning Machine Gun, have been completed and tested so far as possible with the facilities available at Springfield Armory. The mounts have been shipped to Aberdeen Proving Ground, where they will be given a more extensive test.

The four types of receiver sight developed by Springfield Armory have been completed and have been tested here. Seventy-five rifles equipped with these sights have been sent to Fort Benning for field test.

The Thompson Sub-Machine Gun was given an extensive functioning test at this Armory. The report of test has been submitted to the Ordnance Office.

A Gast Machine Gun was tested at this Armory as thoroughly as possible in the absence of magazines, and a study was made of the possibility of adapting any of its mechanical features to other weapons. Report on this test has been submitted to the Ordnance Office.

A. U. S. Rifle, Cal. 30, Model of 1903, equipped with the Ely Battle Control, was tested here and a report submitted to the Ordnance Office.

The Lawrence Machine Gun Tripod was tested here and a study was made of its mechanical construction. Report on this test has been submitted to the Ordnance Office.

The attachment for firing blank ammunition in the .45 caliber automatic pistol as developed by this Armory, has been brought to a stage where it is considered satisfactory for extensive field tests. Springfield Armory has received an order to make up a number of these attachments and send them to troops in the field for further test.

The semi-automatic rifle designed and developed at Springfield Armory by Mr. John C. Garand has been brought to a point where it is possible to conduct preliminary firing with the weapon. A large number of rounds have been fired to date with no serious difficulties, and it is expected that the rifle will be ready for an extensive endurance test within a short time.

The semi-automatic rifle developed at Springfield Armory by Captain James L. Hatcher has been assembled and given a preliminary functioning test, over one thousand rounds having been fired in this gun. Certain adjustments which are being made will permit this gun to enter an extensive endurance test in the near future.

WATERVLIET ARSENAL NOTES

Continued from page 379

will be inserted with a shrinkage of .005 on the diameter. Upon the completion of the relining and repair of this gun the same will be given a thorough test to determine what effect the loss of compression will have upon the serviceability of the gun.

The following table shows in detail the difference in diameter of the A and B Tube between the original when assembled and after the removal of the A Tube. To determine the actual loss of compression of this gun the difference between the actual change of the B Tube and 32/100ths of an inch which was the original calculated compression should be taken:

Distance from Muzzle of Gun	Tube A Change in Diameter *Inch*	Tube B Change in Diameter *Inch*
0	—.0045	—.01
25	0	—.003
50	—.002	—.0045
75	—.002	—.006
100	—.0035	—.006
125	—.004	—.007
150	—.005	—.0075
175	—.003	—.008
200	—.003	—.0075
225	—.002	—.0055
250	—.002	—.0075
275	—.002	—.0095
300	—.0015	—.0055
325	—.005	—.003
350	—.0015	—.007
375	—.0015	—.008
400	—.004	—.006
425	—.0045	—.0053
450	—.007	—.009
475	—.0055	—.003
500	0	0
525	—.002	—.006
550	—.005	—.0055

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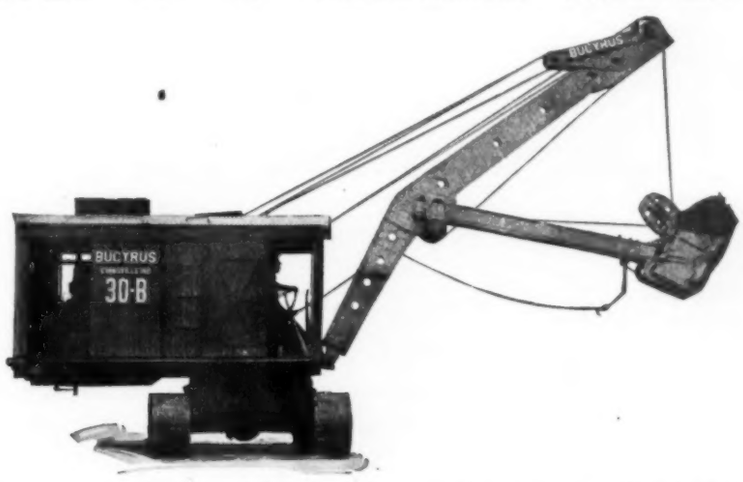

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AIRCRAFT ARMAMENT NOTES

Continued from page 370

available, to build up depleted stocks or to initiate the supply of items heretofore not produced. With but few exceptions, there are now available or approaching completion basic designs of all articles of aircraft armament, the need for which has been brought to the attention of the Ordnance Department, and for those articles for which basic designs have not been completed, a program has been initiated which should lead to their successful development.

The Aircraft Armament Division has thoroughly coordinated the work of the Ordnance Department with the projects of the Air Service. For those who are charged with continuing the work, it is vital that "air knowledge" or "the feel of the air" which can be gained only through frequent flights taken in aircraft, be retained by them in the Ordnance Department so that the items of armament may be intelligently developed and active interest may be continued through actual contact with this new and remarkable combat arm.

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55 Accumulators, complete. Suitable for pressures up to 1500 pounds per square inch or various sizes. Manufactured by Maplewood, Southwark, and Niles. Designed for use with the pumps mentioned above.

Forging Presses—Hydraulic

100 Hydraulic Forging Presses of various sizes. 5 to 750 tons ram pressure. 6-in. to 4-ft. 0-in. ram stroke for hydraulic pressures up to 2500 pounds per square inch. Made by Southwark Mach. Co., Potter & Johnson, and Maplewood, Devilbliss, etc.

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60 Gear and direct driven presses. Belt driven. ¾-in. to 3½-in. stroke. Approximately 100 strokes per minute. Suitable for general stamping work of various sizes. A number of these are new and in original condition.

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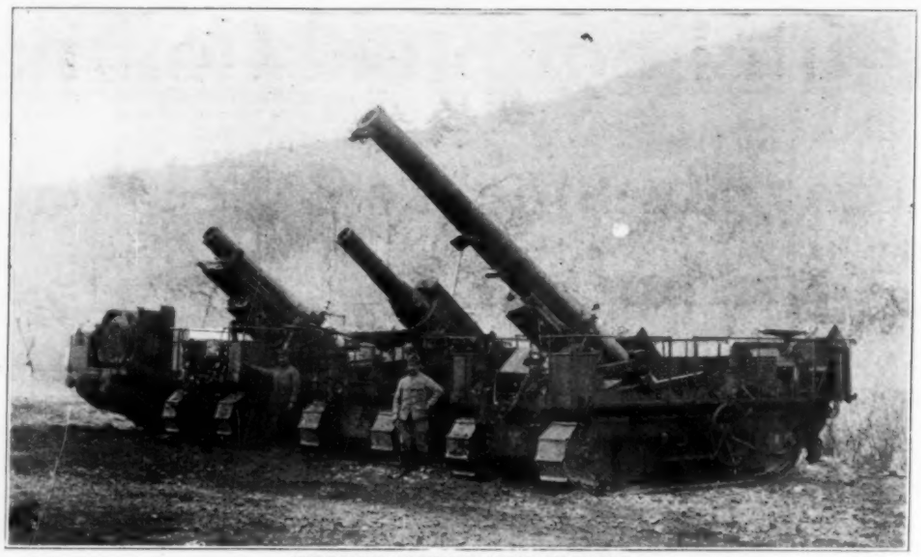

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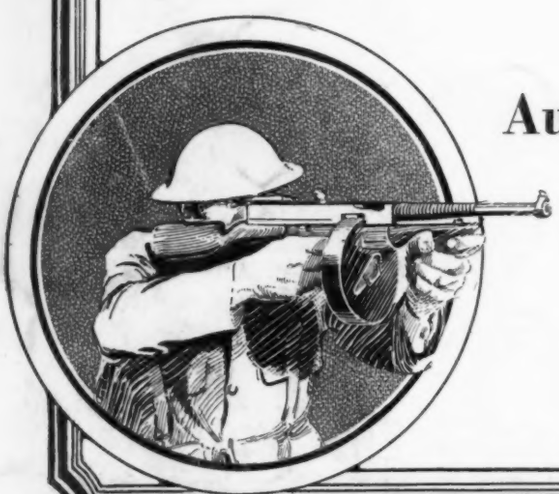

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